Feb. 24, 1953

H. E. ROSE ET AL

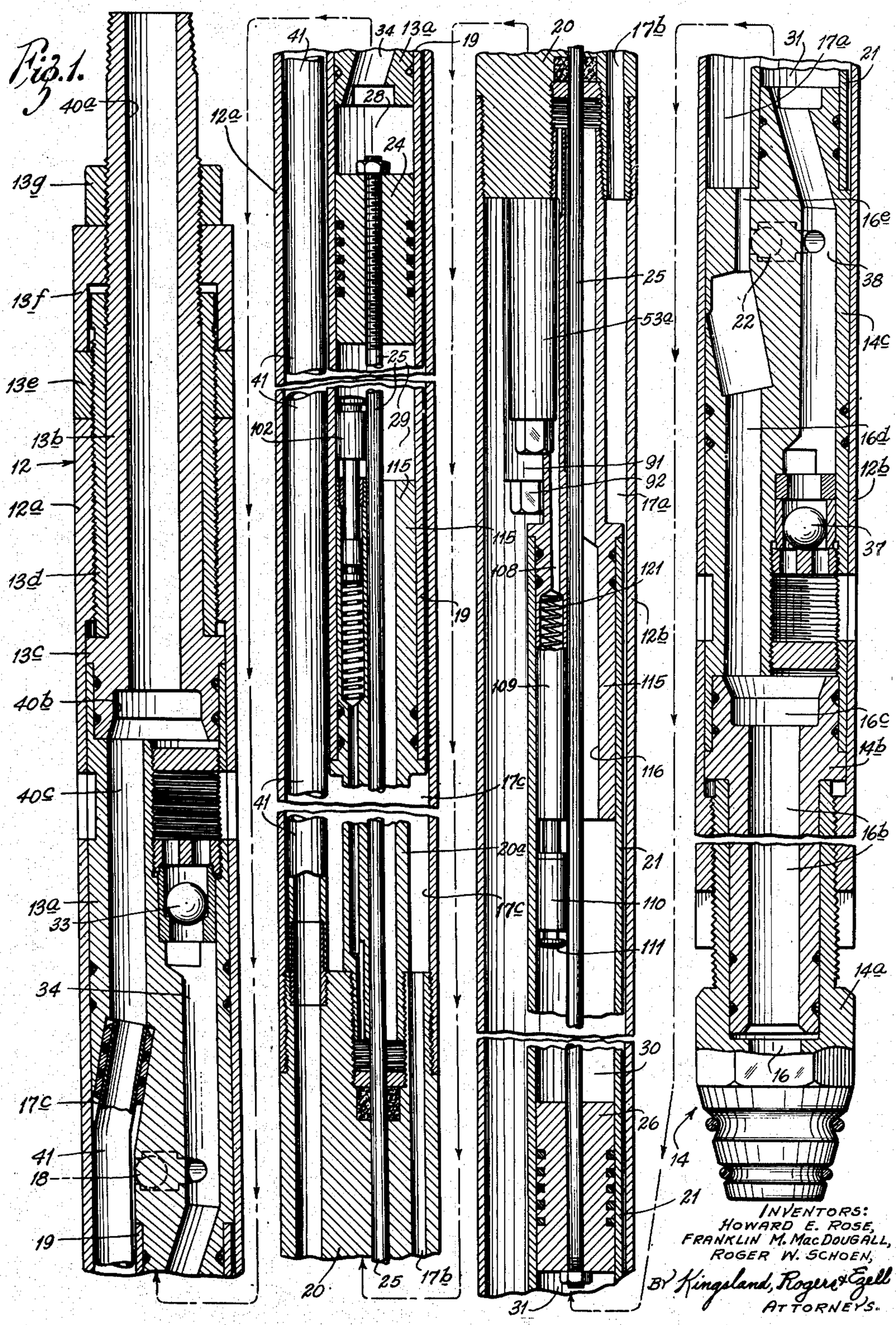
2,629,329

DEEP WELL PUMP

Filed Oct. 4, 1946

2 SHEETS—SHEET 1

Fig. 1.



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2 SHEETS--SHEET 2

Fig. 3.

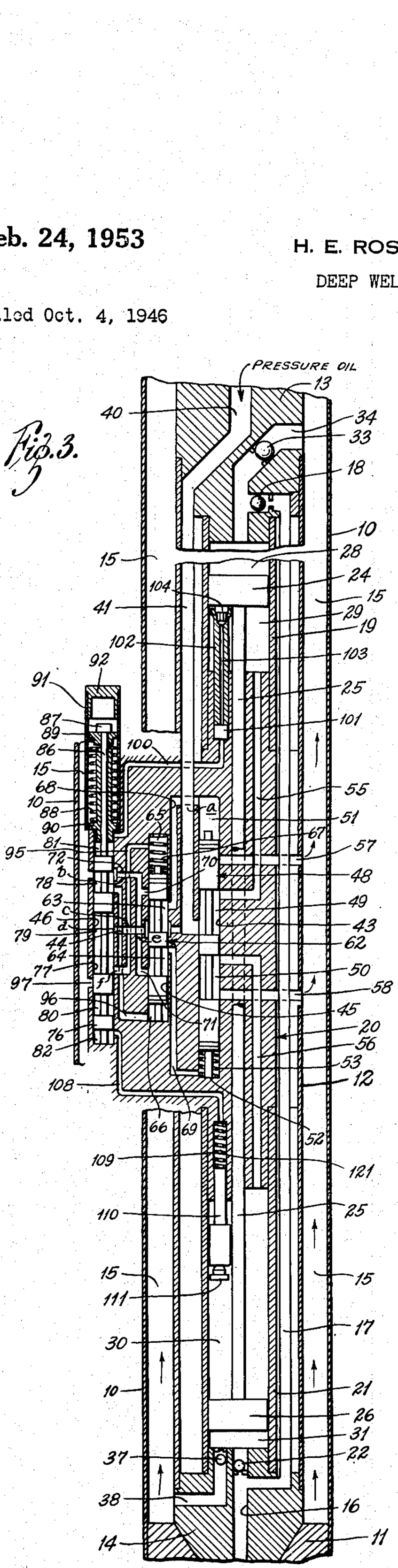
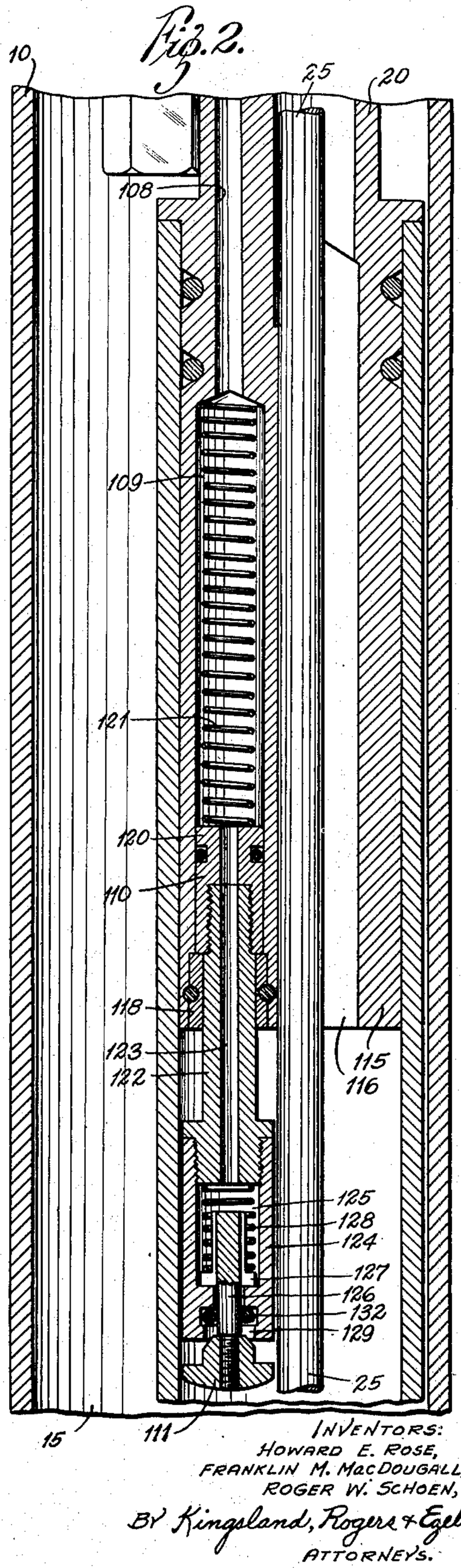


Fig. 2.



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Patented Feb. 24, 1953

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UNITED STATES PATENT OFFICE

2,629,329

DEEP WELL PUMP

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Application October 4, 1946, Serial No. 701,166

17 Claims. (Cl. 103—46)

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The present invention relates to a deep well pumper. That is to say, it has particular advantages in connection with deep well pumping, although it will be understood that its features are applicable to other related operations.

In particular, this pumper is of the type having a pumping mechanism disposed adjacent the bottom of a well and connected by a power oil pipe to the top of the well, in which the power oil is subjected to pressure that produces a pressure condition at the bottom of the well greater than the column of oil being pumped. This power oil is used to cause operation of the pumping mechanism disposed in the bottom of the well.

In the present invention, a valving means is provided for controlling the disposition of this power oil upon pumping piston means. In particular, the pumping mechanism comprises a double-acting piston, having two piston heads each operating in a cylinder. The cylinders, on corresponding sides of the two pistons, are alternately subjected to the power oil, so that the two pistons are alternately driven in opposite directions. The corresponding sides of the cylinders on the opposite sides of the pistons are those which alternately draw oil from the well and eject it into the casing above the pumping mechanism.

It is an object of this invention to provide a valving mechanism for controlling the disposition of the power oil to the pistons alternately, which valving mechanism is reversed by a force produced as the pistons approach the extremes of their strokes. Particularly, it is an object of the invention to provide a valving mechanism which first applies power oil to one piston and then to the other, exhausting the power oil previously supplied to said other piston while it is applying power oil to the first one, and employing pressure developed from the exhausting pressure oil to reverse the valve mechanism.

It is a further object to employ the foregoing system to act as a dashpot means for the pistons. It is a particular object to provide a pumping device and a reversing valve mechanism that relieves the power substantially concurently with the arrival of the piston at the end of its stroke.

More particularly, it is an object of the invention to employ the exhausting power oil from the exhausting piston to charge a reversing pressure chamber on reversing valve mechanism, and then to cause pressure to be applied, through the action of the piston, to the oil thus charged to the pressure chamber, whereby to reverse the valve mechanism.

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A further object of the invention is to provide a dashpot plunger, one end of which is in communication with the pressure chamber of the reversing valve mechanism, and valve means associated with the dashpot plunger, through which the oil from the exhausting cylinder may charge the pressure chamber, in an arrangement by which the valve is closed by the main piston, and which dashpot plunger is thereafter actuated by the main piston, so that the entrapped dashpot oil is then caused to be subjected to pressure that actuates the reversing valve.

Further objects include the provision of means to provide complete piston travel before the piston stops. Particularly, it is an object to provide the complete piston travel through the medium of a pilot valve in the reversing valve mechanism.

A further object is to provide valves that are initially loaded so that they will start the mechanism in the right direction.

In the drawings:

Fig. 1 is a broken view of the pumping mechanism, shown in diametric section;

Fig. 2 is an enlarged view in section of one of the dashpot plungers; and

Fig. 3 is a diagrammatic section showing the valve mechanism.

The mechanism may be understood by referring to Fig. 3, wherein the valve mechanism is developed out of circular arrangement. There is a well casing 10. This well casing 10 has a conventional shoe 11 at its bottom, this shoe being designated diagrammatically in Fig. 3. The shoe has a tapered opening therethrough.

A pumper mechanism comprises a tubular portion 12 having an upper head 13 thereon and a lower head 14 thereon. This lower head is tapered and fits in sealing relation into the tapered opening of the shoe 11. By this means, the pump casing 12, which is smaller in diameter than the well casing 10, provides a space 15 within the casing above the shoe, for the reception of the oil that is pumped.

The lower head 14 has a central passage 16 therethrough that communicates with the supply of oil in the well that is to be pumped. This passage 16 connects with an elongated tube or passage 17 that leads up to the upper head 13.

In the upper head 13, the passage 16 connects through a ball check valve or the line 18 with the upper end of an upper cylinder formed by a cylinder wall member 19 that is attached to the head and is smaller in diameter than the pumper casing 12. The cylinder 19 is connected at its

lower end with a valve mechanism housing, generally designated at 20. The lower end of the valve mechanism housing 20 is connected to a lower cylinder 21 that is attached at its lower end to the head 14. The tube or passage 17 that leads into the head 13 connects across a ball check valve 22 into the lower end of the cylinder 21.

There is a piston 24 reciprocable within the upper cylinder casing 19. This piston is mounted upon a piston rod 25 that slidably passes through the valve housing 20 into the lower cylinder casing 21 where it supports a second piston 26. The two pistons 24 and 26 thereby reciprocate together in their respective cylinders.

The piston 24 divides the cylinder 19 into opposite chambers. The one above the piston 24 is designated at 28; that below the piston 24 is designated at 29. In like manner, the piston 26 divides its cylinder into an upper chamber 30 and a lower chamber 31.

The upper chamber 28 of the piston 24 connects through a ball check valve 33 by way of a passage 34 with the space 15 between the well casing 10 and the pump casing 12. In like manner, the lower chamber 31 below the piston 26 connects across a ball check valve 37 by way of a passage 38 to the space 15.

It may be seen that, when the piston 24 descends, it may open the check valve 18 and close the check valve 33. Likewise, when the piston 26 ascends, it may open the check valve 22 and close the check valve 37.

The pump pistons are actuated oppositely by means of power oil. This oil is introduced into the top of the upper head 13 through a passage 40. It will be understood that the passage 40 is connected by a pipe to the top of the well where a pressure applying mechanism is disposed to maintain a pressure on the oil column at the bottom of the line 40 that is greater than the head of pressure of the oil column being lifted.

The passage 40 in the head 13 connects by a pipe 41 down into the housing 20 for the valve mechanism. In this housing 20, the pipe 41 leads to a mid-portion thereof. This pipe 41 within the valve housing 20 opens directly into a reversing valve cylindrical chamber 43 and is connected by a cross port 44 that, at all times, opens into a pilot valve chamber 45 and a double-acting relief valve cylindrical chamber 46.

The cylinder 43 receives a reversing valve 48 of the three-land type. The three lands provide an upper valve passage 49 and a lower valve passage 50. They also provide an upper pressure chamber 51 and a lower pressure chamber 52, to receive fluid under pressure for the actuation of the valve 48 either up or down. A coil spring 53 in the lower pressure chamber 52 normally urges the valve upwardly.

The valve chamber 43 has a connection by way of a passage 55 leading through the valve housing 20 to the piston chamber 29 below the piston 24. It also has a corresponding passage 56 that leads to the chamber 30 above the piston 26. In addition, it has two exhaust passages 57 and 58 that connect with the receiving space 15. It may be seen that, when the valve 48 is in its indicated position, the pipe 41 is connected through the valve passage 49 with the passage 55 leading to the chamber 29 below the piston 24. The exhaust passage 57 is closed. The lower passage 56 is connected to the exhaust passage 58 by the valve passage 50. It is cut off from the pressure passage 41 by the valve.

The slide valve 48 is adapted to be actuated by power oil applied oppositely to its pressure chambers 51 and 52. This is controlled by a three-land pilot valve 62, that reciprocates within the cylinder 45 in the housing 20.

The three lands provide an upper valve passage 63 and a lower valve passage 64. Above the valve 62, there is a pressure chamber 65, and below it is a pressure chamber 66. A coil spring 67 normally urges the valve 62 downwardly.

The cylinder 45 is connected by an upper passage 68 that leads to the pressure chamber 51 of the valve 48. It is likewise connected by a corresponding passage 69 with the lower pressure chamber 52 of the valve 48. The chamber 45 is also connected toward its opposite ends by ports 70 and 71 with an exhaust passage 72 that constantly opens to the passage 15. As shown, this passage 72 connects with the valve cylinder 46, but is constantly open around the valve therein, as by a groove. The two exhaust ports 70 and 71 are spaced to be controlled by the end lands of the valve 62. The middle land controls the pressure oil port 44.

The valve 62 is actuated by pressure introduced at its opposite pressure chambers 65 and 66 under control of a four-land double-acting pressure relief valve 76 that reciprocates in the cylinder 46. The four lands provide an upper valve passage 78, a middle pasage 79, and a lower passage 80. Above the valve 76, there is a pressure chamber 81, and below it a pressure chamber 82.

The valve 76 is shown in a lower position in Fig. 3. This valve has an extending valve stem 86 projecting into the upper pressure chamber 81. It has a head 87 at its extreme end. Between the head 87 and the first land on the valve, there is a coil spring 88 that acts oppositely against two collars 89 and 90, normally urging them apart. A tubular member 91 is attached into the valve housing 20, and it has a hollow cap 92. In relieved position, the spring 88 causes the collar 89 to move upwardly to engage the cap 92; and it also urges the collar 90 downwardly to engage the end of the valve housing 20 adjacent the fitting of the tube 91. In this position, the two collars 89 and 90 may be in engagement with the cap 92 and the upper valve land, respectively, and the valve will be yieldably maintained in neutral position. When the valve is moved to the position shown, the spring is compressed between the collar 90, which is held against downward movement, and the collar 89 which is forced downwardly. When the valve is moved oppositely from its neutral position, the upper land will engage the collar 90 and force it upwardly, while the collar 89 is held by the cap 92. The two collars 89 and 90 are loosely fitted in their respective parts, so that fluid can flow past them.

The pressure passage 44 connects into the cylinder 46 in the valve passage 79 of the valve 76. The cylinder 46 likewise is connected by a passage 95 to the pressure chamber 65 above the valve 62. The cylinder 46 is likewise connected by a passage 96 with the pressure chamber 66 below the valve 62. It likewise is connected to exhaust through the passage 72 at its upper end and a port 97 at its lower end. These two exhaust ports connect into the space 15 within the outer casing 10.

The opposite ends of the valve 76 are adapted to be connected, respectively, to the inner cylin-

der spaces 29 and 30 of the two pistons 24 and 26. To this end, there is an upper passage 100 leading from the pressure chamber 81 above the valve 76 and connecting into a dashpot cylinder 101. This dashpot cylinder receives a plunger 102 that is ported at 103 with a control valve 104 at the top thereof. The details of this construction will appear hereafter.

In like manner, the lower pressure chamber 82 of the valve 76 is connected by a passage 108 into a lower dashpot cylinder 109 that receives a dashpot plunger 110, controlled by a valve 111, as will appear.

The construction of the dashpot plunger is as shown in Fig. 2. Both of the two dashpot arrangements, that is, the one for the upper piston 24 and the lower piston 26, are identical. Fig. 2 shows the one for the lower piston.

The main valve housing 20 is provided with a cylindrical extension 115 onto which the lower cylinder 21 is secured. The piston rod 25 operates in a cylindrical passage 116 in this extension 115. The extension 115 also receives the end of the passage 108 and the cylinder 109. A collar 118 is sealed into the open end of the cylinder 109.

The piston 110 that reciprocates within the cylinder 109 is a composite member. It consists of a sliding plunger head 120 that is prevented from sliding out the end of the cylinder by the collar 118. It is normally urged by a coil spring 121 toward the collar.

The head 120 receives a threaded projection of a tubular stem 122 that has a passage 123 therethrough. This stem, in turn, receives a valve housing element 124 that is threaded in the manner shown to the stem 122. The member 124 provides a spring chamber 125 that, in return, has a valve stem 126 operating therein. This valve stem has a flange 127 against which a coil spring 128 acts normally to urge the stem outwardly. Outside of the tubular element 124 is the valve head 111 which is secured to the stem 126. The chamber 125 communicates around the valve stem 126 so that fluid flow can take place around the head 111 of the valve and through an axial opening 129, which is of varying diameters, into the spring chamber 125, and thence into the passage 123 to enter the cylinder 109. The valve head is tapered on its inner end and may engage with a sealing ring of resilient material at 132. The taper on the valve head spreads this sealing ring outwardly to engage the walls of the passage 129 and prevent the flow of fluid therethrough. When the valve head 111 is in its outer position, to which it is urged by the coil spring 128, the ring 132 contracts so as to permit the flow of fluid around it.

The head 111 is positioned to be engaged by the upper face of the piston 26 when the piston approaches the end of its stroke. Further movement of the piston 26 will close the valve 111, and thereafter will displace the piston 110 upwardly against the spring 121. This will then displace the liquid entrapped within the cylinder 109 through the passage 108 to the lower end of the valve 76, forcing the same upwardly.

In like manner, the piston 24 can strike its valve 104, closing the same, and thereafter displace the piston 102 downwardly. The two piston constructions and their valve arrangements are identical, although the upper one in Fig. 3 is shown diagrammatically.

In order to show how this pump mechanism is arranged for fitting into a well, the showing of

Fig. 1 is provided. This showing omits the arrangement of the reversing valve mechanism save for certain parts which indicate how it is assembled into the pump casing. Fig. 1 does not show the outer well casing 10.

As shown in Fig. 1, the pump casing 12 is made of several sections. There is an upper section 12*a* which continues down to the reversing valve mechanism housing 20, to which it is threaded, as indicated in the second column of Fig. 1. A lower pump casing section 12*b*, as shown in the third column of Fig. 1, is threaded onto the bottom of the reversing valve housing 20. The upper head 13 likewise is a composite member. It will be seen from the first column of Fig.1 to be fitted into the upper casing element 12*a* it may be slipped upwardly thereinto from the lower part of the casing. Above the portion 13*a* there is a union member 13*b* having a head 13*c* that can be clamped downwardly by a threaded union ring 13*d*, against the top of the front main head member 13*a*. A spacer ring 13*e* is passed over the ring 13*d* and is surmounted by a union cap 13*f* with a final nut 13*g* holding the parts together.

The tubular connector 13*b* contains the upper part 40*a* of the pressure passage. The upper end of the connector 13*b* is adapted to be connected with a power oil pipe leading to the surface.

The lower member 13*c* of the upper member 13*b* has an enlargement 40*b* connecting with the passage 40*a* so that the passage 40a may lead into an off-center passage section 40*c*, regardless of the angular disposition of the upper connector 13*b* relative to the main head portion 13*a*.

The pipe 41 is connected, as shown in the first column of Fig. 1, to the lower part of the passage 40*c*. This pipe leads down to the lower part of the second column of Fig. 1, where it is connected into the housing 20 for the reversing valve mechanism.

The upper head member 13 is connected to the cylinder 19 that is smaller than the pump casing 12. The cylinder 19 is, in turn, connected with an extension 115 of the housing 20, as shown in the first two columns of Fig. 1, and particularly the second one.

The lower head 14 comprises a bottom section 14*a* and is threaded into the bottom of the pumper casing 12*b*, as shown in the fourth column of Fig. 1. It interfits with a second head member 14*b* that has a head received in a recess of a third head portion 14*c*. The lower cylinder 21 is attached to the head member 14*c*. The cylinder 21 extends upwardly and is united at its top to the extension 115 that, at its upper end, is secured to the valve housing 20.

The lower head portion 14 has the inlet passage 16 therethrough. This inlet passage is continued at 16*b* in the head member 14*b*, through the enlargement 16*c* into the passage 16*d* in the head member 14*c*. It opens at 16*e* into the lower space 17*a* above the head 14*c* of the passage designated 17 in Fig. 3.

The housing 20 has an arcuate passage 17*b* therethrough. This connects at its bottom with the space 17*a* and at its top with a similar space 17*c*. The space 17*c* is formed within the upper pump casing 12*a*, which also contains the cylinder 19 and the pipe 41, but ports ample space for the passage of oil upwardly.

The passage 16*e*, in the bottom of the pump, opens through the check valve 22, shown in dotted lines at the upper part of the fourth column of Fig. 1, into the passage 38 above the check

valve 37, which is the equivalent of the structure shown in Fig. 1. At the upper end of the space 17c, there is a connection through the check valve 18, shown in dotted lines at the bottom of the first column of Fig. 1, into the passage 34 that opens downwardly into the interior of the cylinder 19.

The upper piston 24 appears in the second column of Fig. 1, and it is attached by the piston rod 25 with the lower piston 26. The chambers 28 and 29 appear in the second column above and below the piston 24, and the chambers 30 and 31 appear in the third and fourth columns above and below the piston 26.

The extension 91 and cap 92 of the reversing valve mechanism appear above the middle of the third column of Fig. 1. They are here shown as connected into the bottom of the valve housing 20. This is the equivalent structure of that shown in Fig. 3, wherein these parts are shown as connected into the top of the valve housing. Adjacent them is an extension 53a to hold the spring 53 of the reversing valve.

The cylinder chamber 29 below the upper piston 24 contains the upper dashpot plunger 102 that operates in the upper extension 115 of the valve housing. Similarly, the chamber 30 above the piston 26 contains the lower dashpot plunger 110. In Fig. 1, the two pistons 24 and 26 are broken away from the connecting rod 25 for clarity. As shown in Fig. 3, one of them is up when the other is down.

Operation

When the pumping mechanism is to be inserted into a well casing 10, it is connected to the surface by the power oil pipe that is fastened to the upper head member 13b. It is lowered until the lower head 14 seats sealingly with the shoe 11. The passage 16 will thereby be introduced into the oil supply. Power oil is filled into the pipe 40.

At the start, the reversing valve mechanism has the directional valve 48 in its upper position under the influence of the spring 53. The pilot valve 62 is in its lower position under the influence of the spring 67. The relief valve is in a neutral position under the influence of its balancing spring 88.

Power oil will flow through the passage 40 and the passage 41 to the cylinder 43 of the reversing valve and the cross passage 44, from which latter it communicates into the two cylinders 45 and 46.

With the reversing valve 48 upwardly undner the influence of its spring 53, this power oil may flow through the valve passage 50 and the passage 56 to the cylinder 30 above the piston 26. Also, with the pilot valve downwardly under the influence of its spring 67, power oil may flow through the passage 44 and the upper valve passage 63 of the pilot valve to the passage 68 leading into the pressure chamber 51 above the directional valve 48. The lower pressure chamber 52 below the reversing valve 48 is connected to exhaust when the pilot valve 62 is down, because the passageway 69 connects through the lower passage 64 of the pilot valve 62 with the exhaust passage 71 that leads to the space 15. The directional valve will be forced downwardly when the pressure differential between the chambers 51 and 52 produces a force greater than that of the spring 53.

When the directional valve is up, porting power oil to the pump cylinder 30, the pressure in the upper directional valve chamber is insufficient to overcome the spring 53. Hence power oil is ported by the directional valve into the cylinder 30 until that cylinder is filled and its piston 26 is down. When that condition is reached, the power oil will build up pressure in the upper directional valve chamber 51, and the directional valve will be forced down against the spring 53. The spring 53 is thus strong enough to resist valve movement under power oil pressure when the piston is movable, even though there be zero head of oil in the chamber 52.

The lowering of the directional valve 48 introduces the power oil from the pipe 41 through the valve passage 49 and the passage 55 to the chamber 29 below the upper piston 24. At the same time, it ports the chamber 30 above the piston 26 to exhaust into the casing space 15 through the passage 56, the valve passage 50, and the exhaust passage 58.

The introduction of power oil to the chamber 29 below the piston 24 causes this piston to rise and the piston 26 to rise with it. Elevation of the piston 24 first opens the valve 104 and then permits the plunger 102 to be elevated by its spring 121. Oil may then charge the upper dashpot system. The valve 76 is thereby subjected at its top to pressure oil and at its bottom to oil at the pressure produced by the head in the casing space 15. This pressure differential, even with zero casing level head, is insufficient to overcome the force of the spring 88, and the double-acting valve 76 remains in its neutral position. Even if the foregoing were to shift the valve 76, no change would follow, as the valve would be lowered, porting pressure oil to the top chamber 65 of the pilot valve. The spring 67 has already lowered this pilot valve, so no shift occurs if the foregoing takes place.

As the piston 26 rises toward the end of its stroke, it strikes the head 111 of the lower dashpot plunger 110, causing this valve to close, trapping the oil above the valve contained within the cylinder 109, the chamber 82, and the associated passages. This entrapped oil thereupon constitutes a substantially inelastic connection between the piston 26 and the lower end of the double-acting relief valve 76. Continued upward movement of the piston 26 by the action of the pressure oil below the upper piston 24 will cause the entire plunger 110 to be forced upwardly against the spring 121. This action applies pressure to the entrapped oil acting within the lower chamber 82 of the double-acting relief valve, and the continued upward movement of the piston thereby causes the double-acting relief valve to move upwardly against the spring 88. In the upward movement of the valve 76 under force from the piston 26 acting through the connecting entrapped oil, the upper end of the valve 76 can expel oil from the chamber 81 and connected spaces, through the passage 100, and out past the valve 104 that is at such time open. There is a dashpot effect in this action of the valve 76.

It will be understood that, during the upward travel of the piston 26, oil is sucked in from the well through the lower passage 16 and past the check valve 22, this suction maintaining the valve 37 closed. Thus, the lower cylinder 31 is charged with new oil.

The elevating of the double-acting relief valve in the manner aforesaid introduces pressure oil from the passage 44 to the passage 96, which is now connected to the valve passage 79 between the two middle lands of the double-acting valve.

This pressure oil, acting through the passage 96, is delivered to the lower pressure chamber 66 of the pilot valve 62. At the same time, the upper chamber 65, which contains the spring 67, is ported through the passage 95 to exhaust by the upward movement of the double-acting relief valve which connects the outlet of the passage 95 with the exhaust passage 97. Thus the pilot valve is moved upwardly by this shift.

When the pilot valve moves upwardly, it connects the pressure oil from the passage 44 to the valve passage 64 with the line 69 leading to the lower pressure chamber 52 below the reversing valve. At the same time, it ports the upper chamber 51 above the reversing valve through the passage 68 with exhaust by way of the valve passage 63 and the exhaust passages 70 and 72. Meanwhile the exhaust passage 71 is cut off by the bottom land of the valve 62.

The reversing valve is, by the foregoing action, moved upwardly. As will be understood, this shifting of the reversing valve cuts the cylinder 29 below the piston 24 to exhaust by way of the valve passage 49 and the exhaust passage 57, so that this pressure oil may enter the space 15. It also cuts the pressure oil through the lower passage 50 of the reversing valve into the passage 56 that leads to the chamber 30 above the piston 26.

The foregoing action produces a quick reversal of the pressure acting in the cylinders 29 and 30. At the end of the power stroke, the power is thus cut off and reversed, so that impacting of the moving pistons upon the fixed parts is at least greatly reduced.

When the valves have reversed, the power oil is directed into the cylinder 30 to drive the piston 26 down, carrying the piston 24 with it. Lowering of the piston 26 drives the fresh oil sucked from the well into the pumping cylinder 31, out past the valve 37 into the casing space 15. At the same time, the upper piston 24 sucks new oil into the top cylinder 28, past the valve 18.

When the piston 26 is lowered a short distance, the plunger 110 is returned to starting position and the valve 111 opened, for release of pressure in the double-acting valve chamber 82. With both valves 104 and 111 open, the net pressure differential acting upon the valve 76, in its valve chambers 81 and 82, again reduces until it is insufficient to overcome the spring 88, it being noted that the oil acting about the spring and associated parts produces forces that balance except for that upon the head of the valve. The valve 76 returns to neutral position, trapping the pressure positioning the pilot valve and holding that valve in its set position until the relief valve is later moved oppositely from neutral position by the action of the upper plunger 102 depressed by the upper piston 24 toward the end of the downstroke.

The foregoing cycle will repeat itself automatically, each stroke delivering fresh oil to the casing space 15.

The relief valve spring 88 is calibrated to suit the conditions of the well wherein the pump is used. After the casing has been filled with oil, this valve is subjected to casing head pressure at one end and power oil pressure at the other, which is a minimum differential. However, at the start, with a dry casing, this valve is subjected at one end to power oil pressure and at its other end to zero gauge pressure. The spring must be strong enough to resist movement under this maximum differential. It is designed

to permit movement only when the greater force produced by the dashpot plunger is applied to it. This force is a function of the area of the pistons 24 and 26 to the area of the plungers 102 and 110. This spring may be regulated to the well depth, as power oil pressure is a function thereof.

The pilot and directional valves are oppositely spring loaded to assure that the pump will start properly and not hang up, either in a dry casing or in one containing a head of oil. Relief of the power oil pressure will subject each of the valves to the static power oil head at one end, and to the static casing oil head at the other. The springs 53 and 67 are strong enough to bias the valves against a maximum static differential between these pressures.

The pilot valve 62, in combination with the directional valve 48, prevents a wire-drawn pump stroke. If the pilot valve were not used, and the directional valve were operated directly by the relief valve, the directional valve might be cracked open in a reversing direction, and the piston reversed to release the relief valve back to neutral before the directional valve is fully open. A slow pump stroke, or even a block, could result. The present arrangement avoids this. The pilot valve must shaft partially before the directional valve can move. The relief valve cannot neutralize until the directional valve moves. Hence the pilot valve must reverse at least partially before the relief valve neutralizes, and the directional valve is assured of a complete, if delayed, full stroke. The pump will thus be assured of receiving full pressure of the power oil for each stroke.

What is claimed is:

1. A mechanism of the kind described, comprising a cylinder means, piston means operated therein by pressure differential in the cylinder means on opposite sides thereof, a fluid pressure line, valve mechanism movable from a position connecting the line to the cylinder means for admitting pressure from the line to the cylinder means to effect movement of the piston means, to a position relieving the said cylinder means from said pressure that produces movement, fluid pressure-responsive mechanism movable to operate the valve mechanism to relieving position, movable means operated by the piston means as it approaches the end of its stroke, to produce a pressure that actuates the fluid pressure-responsive mechanism, said last means including a plunger engageable by the piston means, a fluid cylinder in which the plunger is movable, and spring means opposing movement of the plunger by the piston means.

2. A mechanism of the kind described, comprising a cylinder means, piston means operated therein by pressure differential in the cylinder means on opposite sides thereof, a fluid pressure line, valve mechanism movable from a position connecting the line to the cylinder means for admitting pressure from the line to the cylinder means to effect movement of the piston means, to a position relieving the said cylinder means from said pressure that produces movement, fluid pressure-responsive mechanism movable to operate the valve mechanism to relieving position, movable means operated by the piston means as it approaches the end of its stroke, to produce a pressure that actuates the fluid pressure-responsive mechanism, said last means including a plunger engageable by the piston means, a fluid cylinder in which the plunger is movable, and a valve between the fluid cylinder and the cylinder

means, the valve being closed upon operation of the plunger by the piston means.

3. A mechanism of the kind described, comprising a pair of cylinders, a pair of connected pistons, one in each cylinder, a reversing valve mechanism for connecting the cylinders alternately to a fluid pressure source, the reversing valve mechanism including a reversing directional valve, and fluid pressure-responsive means for actuating the same to each of its positions, the last means including opposite fluid pressure chambers and mechanism operated thereby to control operation of the valve, a movable wall means closing each fluid pressure chamber and engageable by each piston at the latter end of its stroke, each wall means being adapted to reduce the capacity of one fluid pressure chamber and thereby produce fluid pressure therein, whereby the fluid pressure-responsive means may be operated to reverse the directional valve.

4. A mechanism of the kind described, comprising a pair of cylinders, a pair of connected pistons, one in each cylinder, a reversing valve mechanism for connecting the cylinders alternately to a fluid pressure source, the reversing valve mechanism including a reversing directional valve, and fluid pressure-responsive means for actuating the same to each of its positions, said last means including a pair of fluid containing chambers, a movable wall for each chamber and in each cylinder, one movable wall being engageable by each piston and moved thereby at the end of the piston stroke, to produce pressure in its chamber to actuate the fluid pressure-responsive means and effect reversal of the directional valve.

5. A mechanism of the kind described, comprising a pair of cylinders, a pair of connected pistons, one in each cylinder, a reversing valve mechanism for connecting the cylinders alternately to a fluid pressure source, the reversing valve mechanism including a reversing directional valve, opposite pressure chambers associated with the directional valve adapted to receive fluid under pressure for oppositely shifting the valve, means for porting fluid pressure alternatively into the chambers, including a double-acting relief valve normally yieldably maintained in neutral position, additional opposite pressure chambers for receiving pressure fluid for oppositely displacing the relief valve from neutral position, a movable wall in each additional chamber, each wall being displaced by movement of one piston at the end of its stroke, for applying pressure in its pressure chamber to displace the relief valve and effect reversal of the directional valve.

6. A mechanism of the kind described, comprising a pair of cylinders, a pair of connected pistons, one in each cylinder, a reversing valve mechanism for connecting the cylinders alternately to a fluid pressure source, the reversing valve mechanism including a reversing directional valve, opposite pressure chambers associated with the directional valve adapted to receive fluid under pressure for oppositely shifting the valve, means for porting fluid pressure alternatively into the chambers, including a double-acting relief valve normally yieldably maintained in neutral position, additional opposite pressure chambers for receiving pressure fluid for oppositely displacing the relief valve from neutral position, a movable wall in each additional chamber, each wall being displaced by movement of one piston at the end of its stroke, for applying pressure in its pressure chamber to displace the relief valve and effect reversal of the directional valve, and the porting means including a pilot valve between the relief valve and the directional valve, the relief valve being adapted to effect shifting of the pilot valve, and the pilot valve effecting the porting of fluid to the chambers of the directional valve.

7. A mechanism of the kind described, comprising a pair of cylinders, a pair of connected pistons, one in each cylinder, a reversing valve mechanism for connecting the cylinders alternately to a fluid pressure source, the reversing valve mechanism including a reversing directional valve, opposite pressure chambers associated with the directional valve adapted to receive fluid under pressure for oppositely shifting the valve, means for porting fluid pressure alternatively into the chambers, including a double-acting relief valve normally yieldably maintained in neutral position, additional opposite pressure chambers for receiving pressure fluid for oppositely displacing the relief valve from neutral position, a movable wall in each additional chamber, each wall being displaced by movement of one piston at the end of its stroke, for applying pressure in its pressure chamber to displace the relief valve and effect reversal of the directional valve, and the porting means including a pilot valve between the relief valve and the directional valve, the relief valve being adapted to effect shifting of the pilot valve, and the pilot valve effecting the porting of fluid to the chambers of the directional valve, means normally urging the pilot valve into a position to port the pressure fluid to displace the directional valve to one position, and means normally urging the directional valve into its opposite position.

8. A fluid pressure mechanism including a cylinder, a piston, a valve to control admission of fluid to the cylinder to act upon the piston, a pressure operated device for controlling actuation of the valve, including a pressure chamber, a plunger movable to vary the size of the chamber and produce fluid pressure conditions, a passage through the plunger, a valve operable to open and close the passage, the valve being supported on the plunger for engagement by the piston, whereby movement of the piston may close the valve, and the plunger being thereafter displaceable by further movement of the piston.

9. A fluid pressure mechanism including a cylinder, a piston, a valve to control admission of fluid to the cylinder to act upon the piston, a pressure operated device for controlling actuation of the valve, including a pressure chamber, a plunger movable to vary the size of the chamber and produce fluid pressure conditions, a passage through the plunger, a valve operable to open and close the passage, the valve being supported on the plunger for engagement by the piston, whereby movement of the piston may close the valve, and the plunger being thereafter displaceable by further movement of the piston, and spring means between the valve and the plunger to urge the valve into open position.

10. A fluid pressure mechanism including a cylinder, a piston, a valve to control admission of fluid to the cylinder to act upon the piston, a pressure operated device for controlling actuation of the valve, including a pressure chamber, a plunger movable to vary the size of the chamber and produce fluid pressure conditions, a passage through the plunger, a valve operable to open and close the passage, the valve being supported on the plunger for engagement by the piston, whereby movement of the piston may close the valve,

and the plunger being thereafter displaceable by further movement of the piston, and spring means acting on the plunger in opposition to the force of the piston thereon.

11. A pumping mechanism including two cylinders, a pair of pistons, one in each cylinder, connecting means joining the two pistons, being connected to one piston face of each piston, the pistons dividing their cylinders into two cylindrical spaces in each cylinder, the two spaces through which the connecting means extends being designated inner cylinders, and the two such spaces on the opposite sides of the two pistons being designated outer cylinders, there being liquid inlet passages from the bottom of the pump to the said outer cylinders and liquid outlet passages from said outer cylinders, a power liquid line adapted to contain liquid under pressure, reversing valve mechanism including a housing between the cylinders, a passage in the housing connected to the power line, a directional valve, each inner cylinder having a first passage connecting it with the directional valve and an exhaust passage, the directional valve being movable to connect the power passage with the first passage of one inner cylinder and to connect the other inner cylinder with its exhaust passage, and vice versa, a pair of opposite pressure chambers for the directional valve, spring means normally urging the directional valve into one position, a pilot valve in the housing movable to connect one of said pressure chambers of the directional valve with the power passage and the other with the receiving conduit, and vice versa, opposite pressure chambers for the pilot valve, spring means normally urging the pilot valve to a position to port pressure liquid to the directional valve to move it against its spring, the directional valve spring having a strength, and being adapted to hold the directional valve against such movement, so that pressure liquid may be ported through the directional valve to a piston, until the piston is in an extreme position and pressure is thereafter built up in the power passage, and ported through the pilot valve to shift the directional valve, a double-acting relief valve in the housing, movable to connect either pilot pressure chamber to the power passage and the other to the receiving conduit, means normally yieldably maintaining the relief valve in neutral position wherein liquid is trapped in the pilot valve pressure chambers, a pair of opposite pressure chambers for the relief valve, one connected to each inner power cylinder, a plunger projecting into each inner cylinder and each said relief valve pressure chamber connections, and engageable by the piston in such cylinder to be displaced thereby and to build up pressure in the pressure chamber to displace the relief valve, reverse its connections with the pilot valve chambers, shift the pilot valve, and thereby effect shifting of the directional valve to reverse the pistons.

12. In a mechanism of the kind described, a cylinder, a piston in the cylinder having first means to operate it in one direction, fluid pressure means for operating it in the other direction, valve mechanism operable to connect the cylinder to fluid under pressure as the piston approaches the end of its stroke by said first means, said valve mechanism including a fluid pressure operated valve having a pressure chamber connected with the cylinder, a displacement member in the chamber and operable by the piston as the piston approaches the end of its

stroke produced by said first means, a second valve associated with the pressure chamber to admit fluid from the cylinder to the chamber when the second valve is open, and the second valve being arranged to be closed when the piston operates the displacement member to trap the fluid in the chamber, the trapped fluid constituting a connecting means between the piston and the fluid pressure operated valve, that is displaced by the displacement member in its movement by the piston, to move the fluid pressure operated valve, and means operable upon movement of the fluid pressure operated valve as aforesaid, to admit fluid to the cylinder to operate the piston in its other direction.

13. In a mechanism of the kind described, a cylinder, a piston in the cylinder having first means to operate it in one direction, fluid pressure means for operating it in the other direction, valve mechanism operable to connect the cylinder to fluid under pressure as the piston approaches the end of its stroke by said first means, said valve mechanism including a fluid pressure operated valve having a pressure chamber connected with the cylinder, a displacement member in the chamber and operable by the piston as the piston approaches the end of its stroke produced by said first means, a second valve associated with the pressure chamber to admit fluid from the cylinder to the chamber when the second valve is open, and the second valve being arranged to be closed when the piston operates the displacement member to trap the fluid in the chamber, the trapped fluid constituting a connecting means between the piston and the fluid pressure operated valve, that is displaced by the displacement member in its movement by the piston, to move the fluid pressure operated valve, means operable upon movement of the fluid pressure operated valve as aforesaid, to admit fluid to the cylinder to operate the piston in its other direction, and means normally urging the second valve to open position.

14. In a mechanism of the kind described, a cylinder, a piston in the cylinder having first means to operate it in one direction, fluid pressure means for operating it in the other direction, valve mechanism operable to connect the cylinder to fluid under pressure as the piston approaches the end of its stroke by said first means, said valve mechanism including a fluid pressure operated valve having a pressure chamber connected with the cylinder, a displacement member in the chamber and operable by the piston as the piston approaches the end of its stroke produced by said first means, a second valve associated with the pressure chamber to admit fluid from the cylinder to the chamber when the second valve is open, and the second valve being arranged to be closed when the piston operates the displacement member to trap the fluid in the chamber, the trapped fluid constituting a connecting means between the piston and the fluid pressure operated valve, that is displaced by the displacement member in its movement by the piston, to move the fluid pressure operated valve, and means operable upon movement of the fluid pressure operated valve as aforesaid, to admit fluid to the cylinder to operate the piston in its other direction, the displacement member comprising a plunger projecting into the cylinder in the path of the piston, having sliding engagement with the walls of the chamber, and having a passage therethrough connecting the chamber and the cylin-

der, the second valve being mounted on the displacement member to close the passage, and having a part projecting into the path of the piston to be engaged thereby in the piston movement aforesaid, so that the piston can close the valve and then move the displacement member.

15. In a mechanism of the kind described, a pair of connected cylinders, a pair of connected pistons operating in the respective cylinders for reciprocation together, mechanism to admit fluid under pressure to the first cylinder to act upon the first piston to displace the two pistons in one direction, and to admit fluid under pressure to the second cylinder to act upon the second piston to displace the two pistons in the opposite direction, said mechanism including a fluid pressure operated valve having opposite fluid chambers for its opposite displacement, each chamber being connected with one of the cylinders, a plunger in each chamber, projecting into its cylinder to be engaged by its piston toward the end of the stroke thereof and displaced thereby, second valve means to close each chamber from its cylinder, arranged to be closed when the piston in such cylinder displaces its plunger, and to be opened at other times to admit fluid to the chamber, closure of the second valve trapping the fluid in the chamber so that movement of the piston at the end of its stroke displaces fluid in the chamber to move the fluid pressure operated valve, means operated by the movement of the fluid pressure operated valve by one piston, as aforesaid, to relieve fluid pressure from the cylinder theretofore receiving pressure, and to admit fluid pressure to the other cylinder.

16. In a mechaism of the kind described, a pair of connected cylinders, a pair of connected pistons operating in the respective cylinders for reciprocation together, mechanism to admit fluid under pressure to the first cylinder to act upon the first piston to displace the two pistons in one direction, and to admit fluid under pressure to the second cylinder to act upon the second piston to displace the two pistons in the opposite direction, said mechanism including a fluid pressure operated valve having opposite fluid chambers for its opposite displacement, each chamber being connected with one of the cylinders, a plunger in each chamber, projecting into its cylinder to be engaged by its piston toward the end of the stroke thereof and displaced thereby, second valve means to close each chamber from its cylinder, arranged to be closed when the piston in such cylinder displaces its plunger, and to be opened at other times to admit fluid to the chamber, closure of the second valve trapping the fluid in the chamber, so that movement of the piston at the end of its stroke displaces fluid in the chamber to move the fluid pressure operated valve, means operated by the movement of the fluid pressure operated valve by one piston, as aforesaid, to relieve fluid pressure from the cylinder theretofore receiving pressure, and to admit fluid pressure to the other cylinder, said last-named means including a directional valve, and opposite fluid pressure chambers to operate it, said fluid pressure chambers of the directional valve being connected to pressure and exhaust respectively, by the displacement of the first-named fluid pressure operated valve in the manner aforesaid.

17. In a mechanism of the kind described, a cylinder, a piston oppositely movable therein, means for moving the piston in one direction, fluid pressure means for operating it in the other direction, mechanism for controlling admission of fluid pressure to the cylinder, to admit the same for fluid pressure operation of the piston and to exhaust it for operation of the piston by the first-named moving means, said mechanism including a directional valve displaceable to admit fluid to the cylinder and to exhaust the same, fluid pressure chambers at opposite ends of the directional valve to operate it by fluid pressure, means including a relief valve normally yieldably maintained in neutral position, movable in one direction therefrom to admit fluid pressure to one fluid pressure chamber of the directional valve and in the opposite direction to admit fluid to the other chamber thereof, force transmitting means to connect the relief valve to the piston when the piston approaches the end of its stroke by the first piston moving means, to cause the piston to shift the relief valve from neutral position to admit fluid pressure to the directional valve to shift it to admit fluid pressure to the cylinder, and force transmitting means to connect the relief valve to the piston when the piston approaches the end of its fluid pressure stroke, to cause the piston to shift the relief valve oppositely and effect relief of pressure within the cylinder, the relief valve having means returning it to neutral position when the piston is not at an extreme position, and having means closing both fluid pressure chambers when in said position.

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