July 16, 1957 R. W. SCHOEN 2,799,225

DEEP WELL PUMP

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Fig. 1.

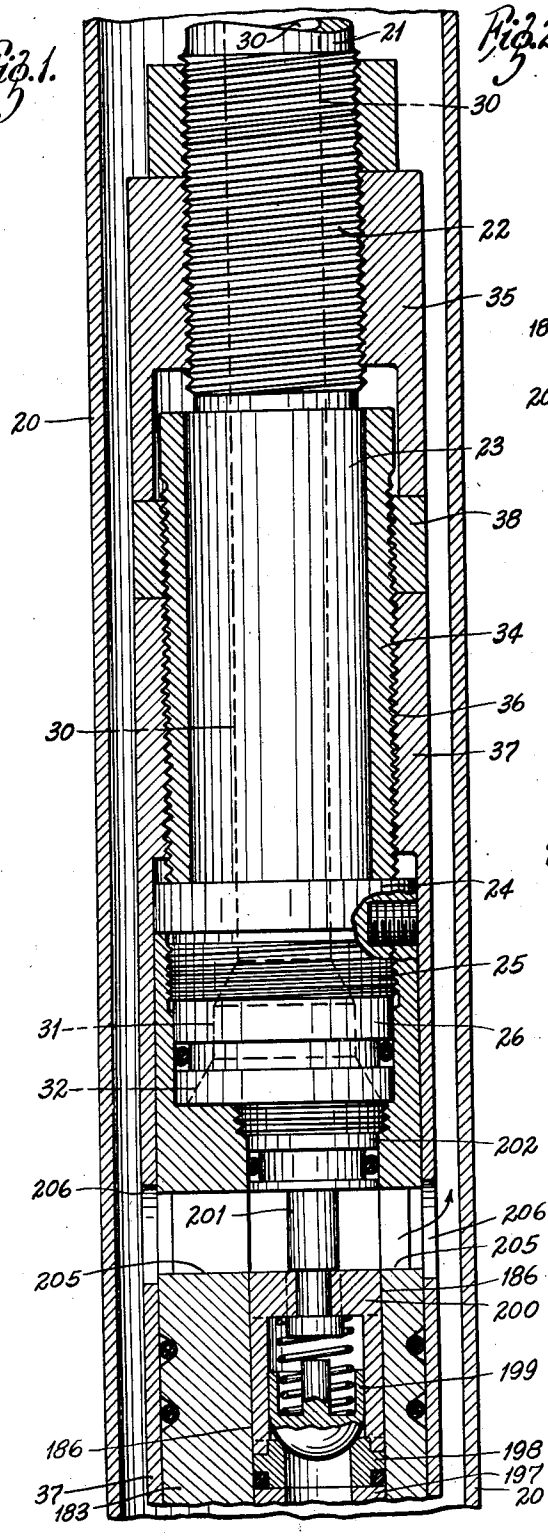
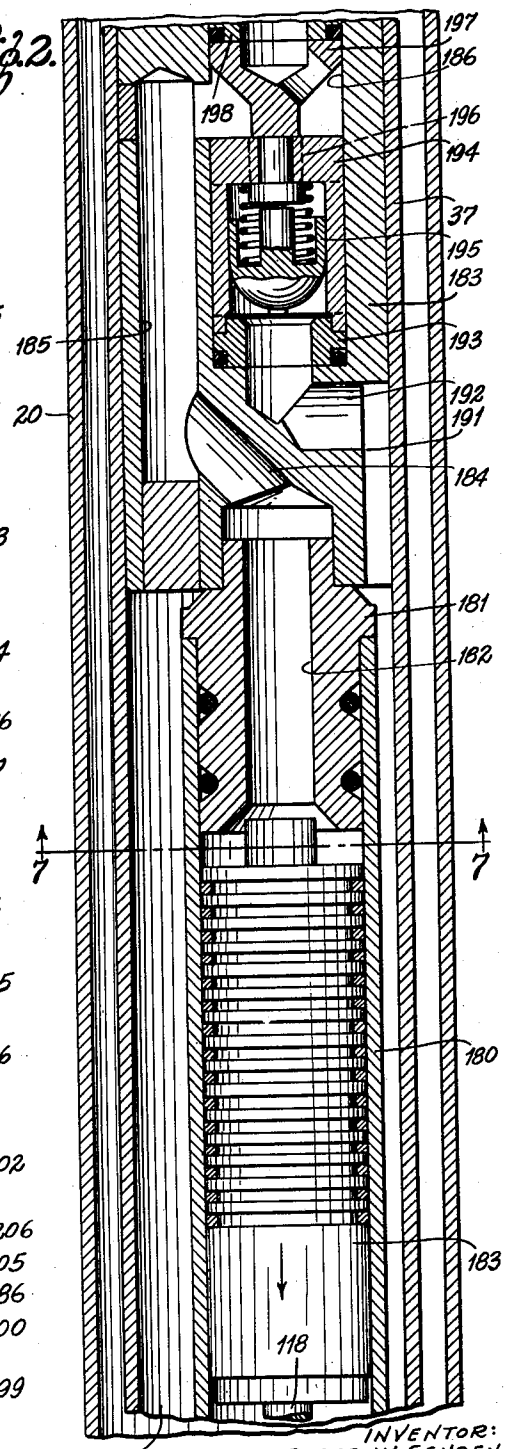


Fig. 2.



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Fig. 3.

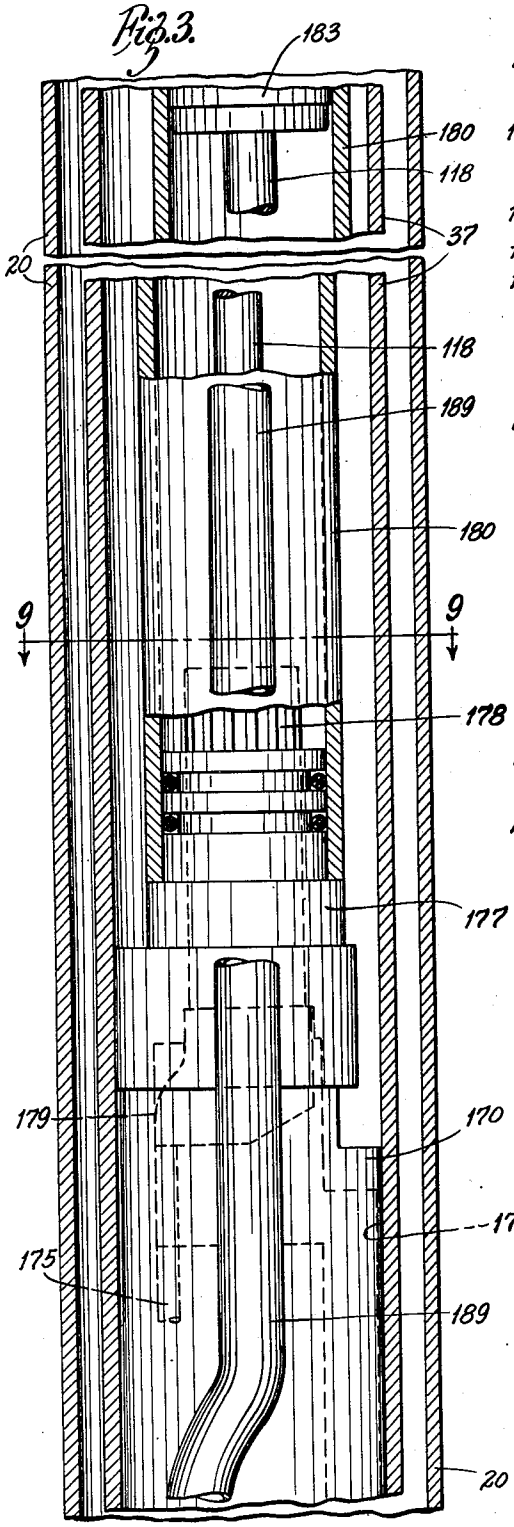


Fig. 7.

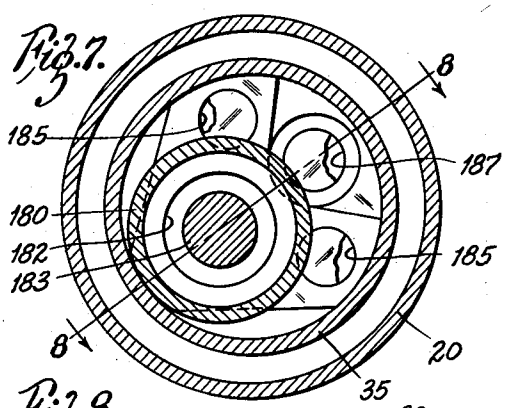
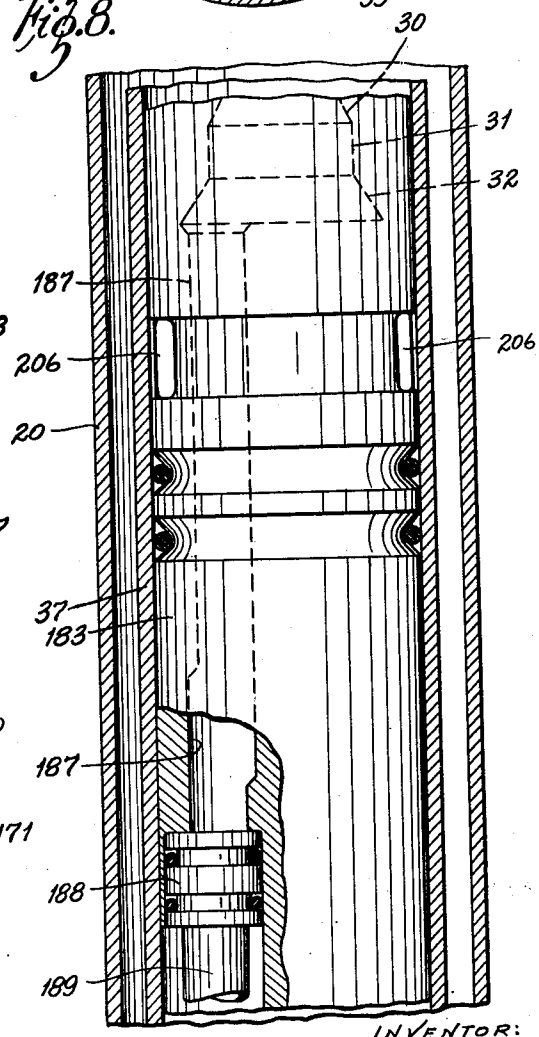


Fig. 8.



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Fig. 10.

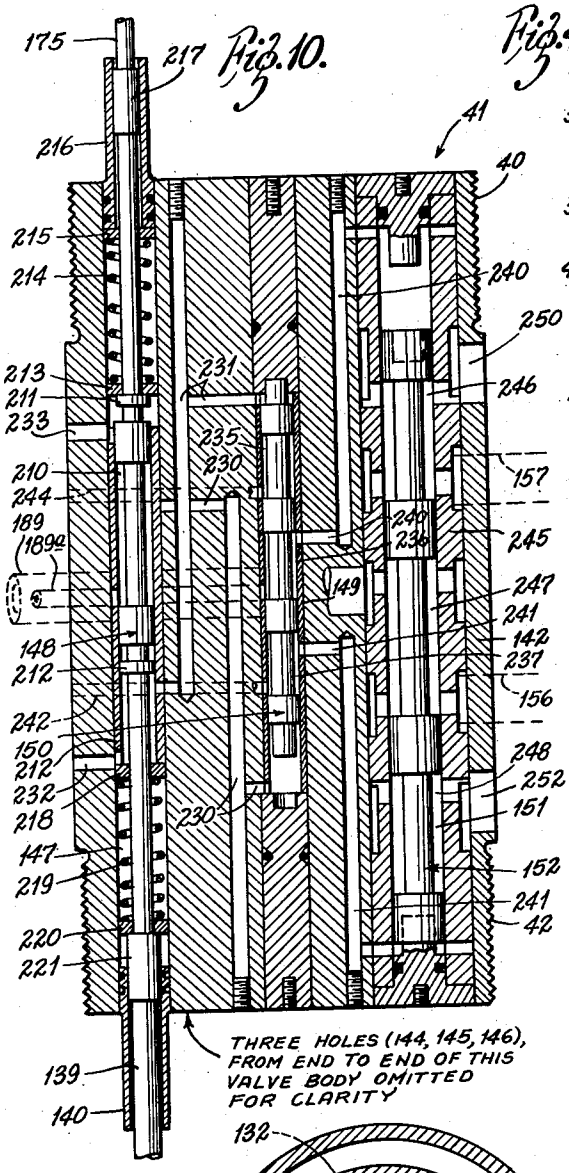


Fig. 9.

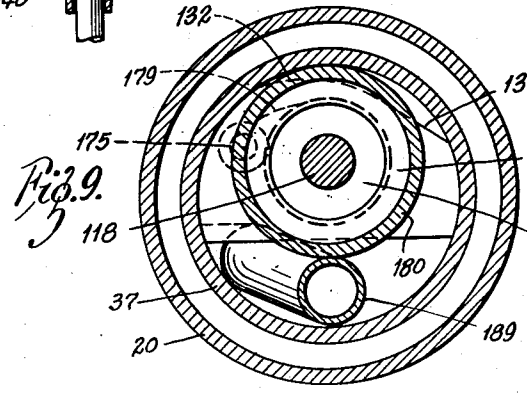
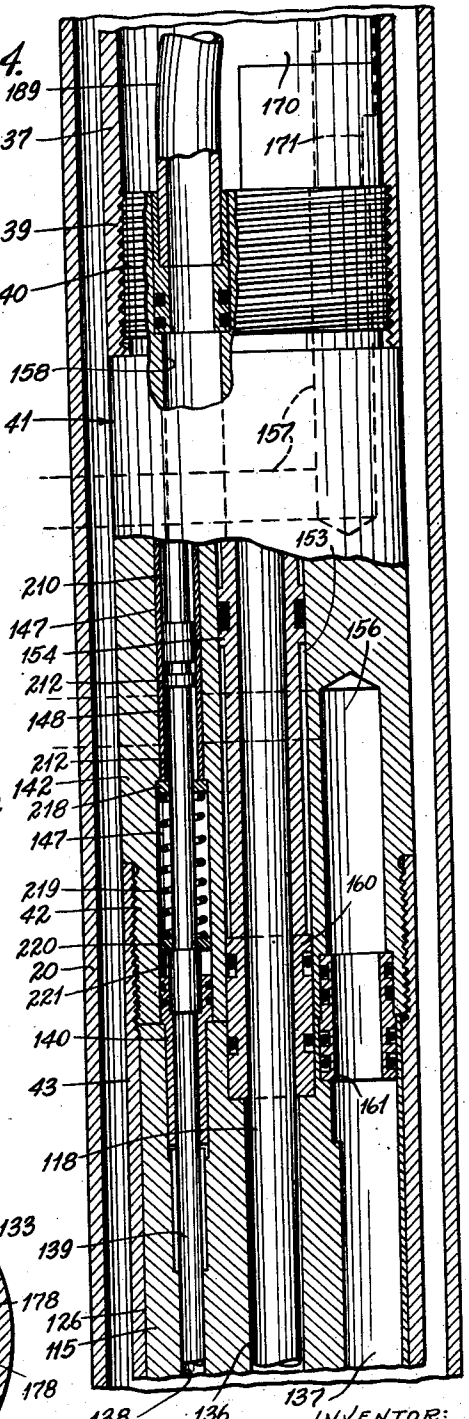


Fig. 4.



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Fig. 5.

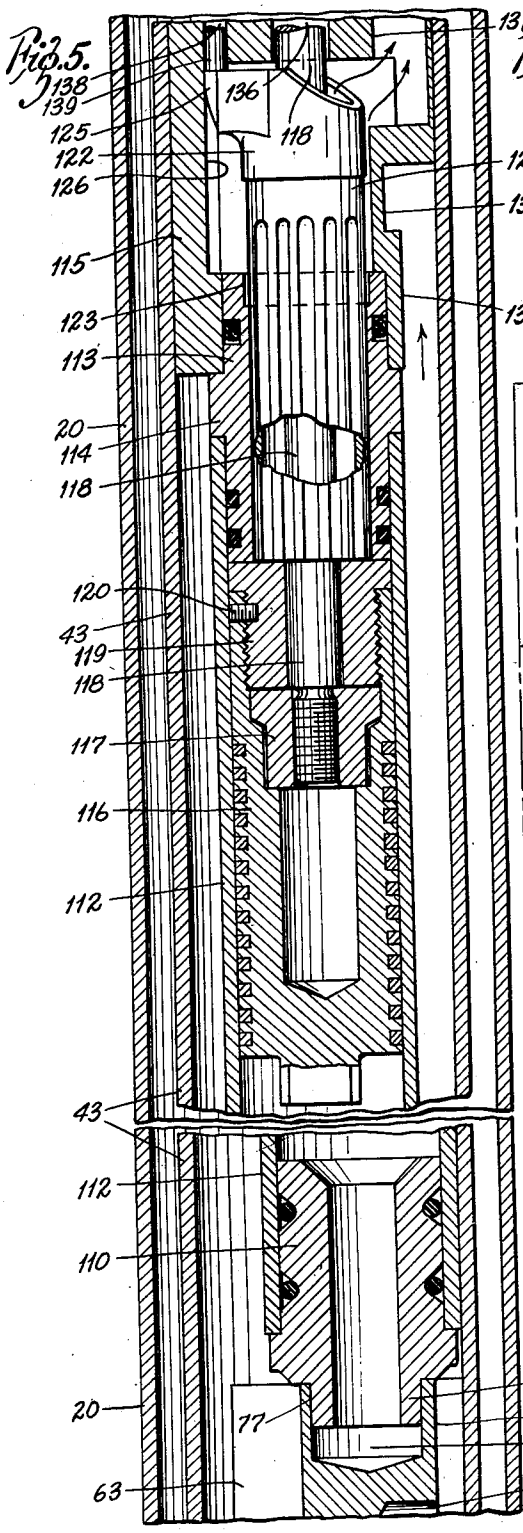
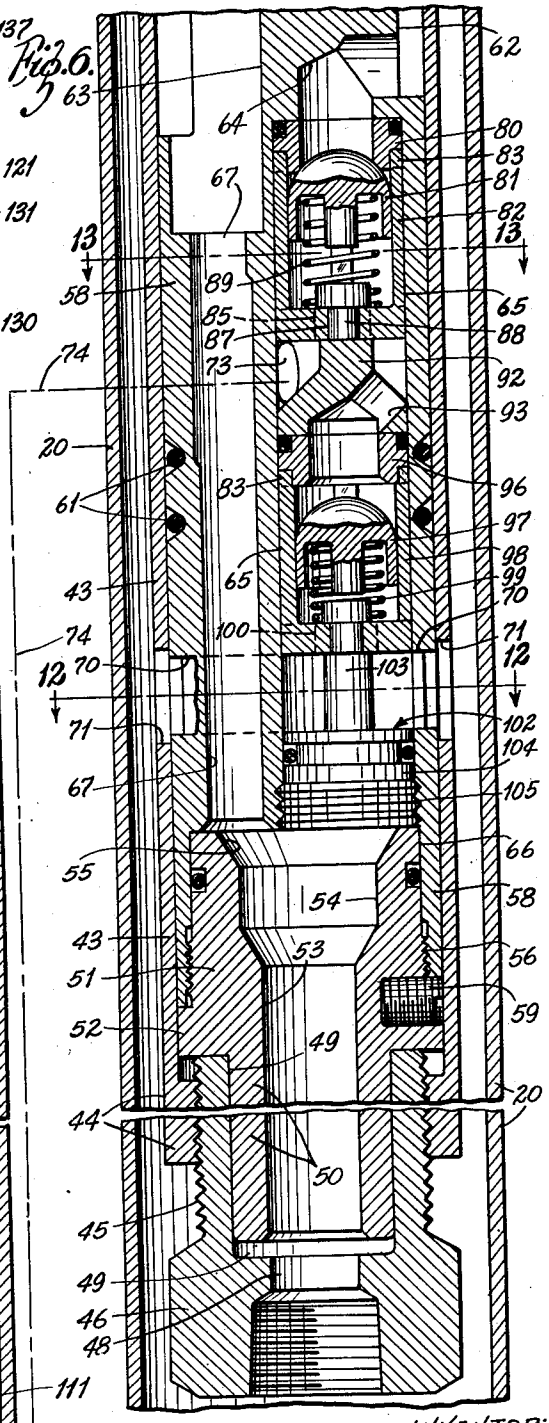


Fig. 6.



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Fig. 11.

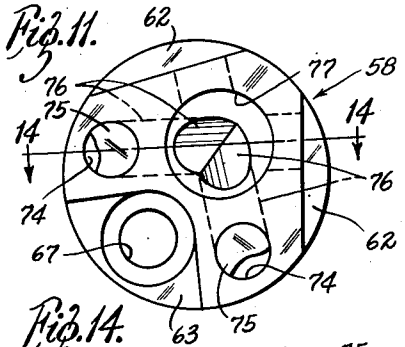


Fig. 12.

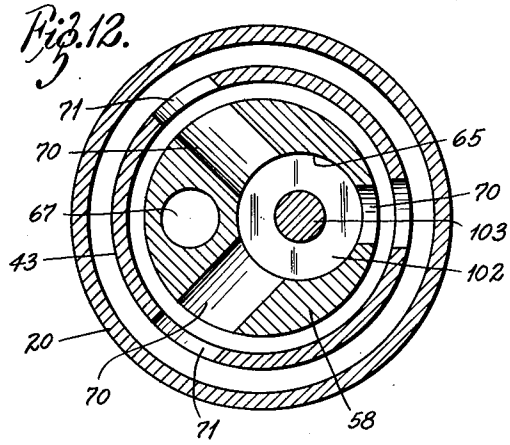


Fig. 14.

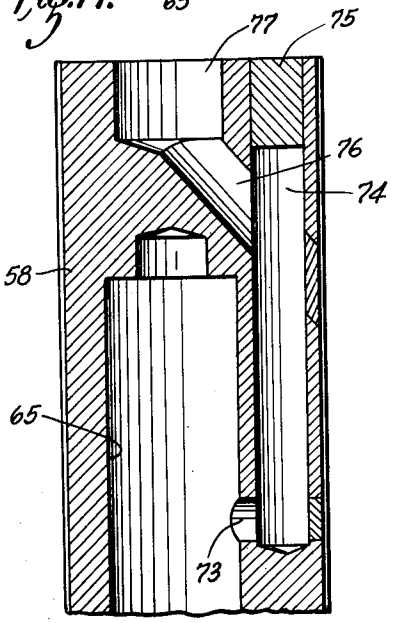


Fig. 13.

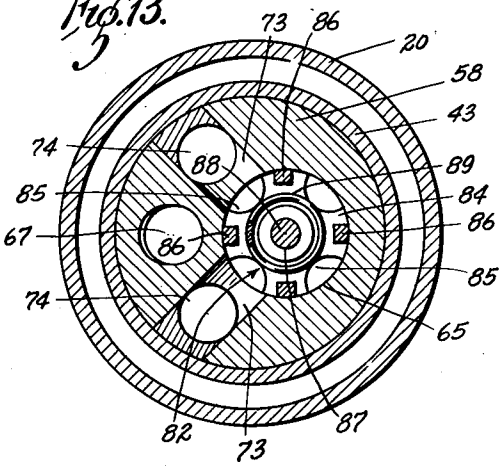


Fig. 17.

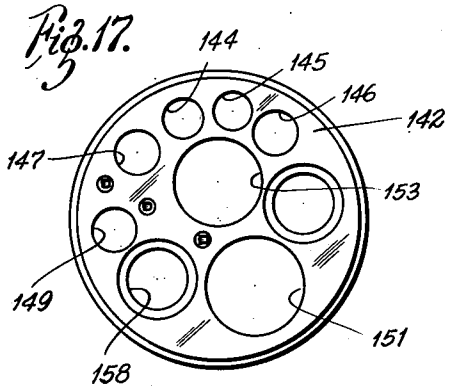


Fig. 15.

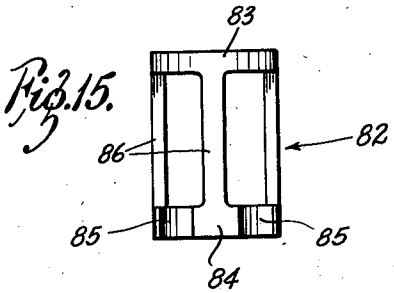
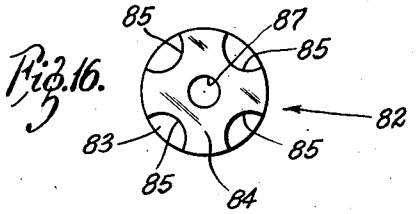


Fig. 16.



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United States Patent Office 2,799,225 Patented July 16, 1957

2,799,225

DEEP WELL PUMP

Roger W. Schoen, Mineral Wells, Tex., assignor to Alco Valve Company, University City, Mo., a corporation of Missouri

Application October 7, 1953, Serial No. 384,732

12 Claims. (Cl. 103—46)

The present invention relates to a pumping mechanism and has particular reference to a pump of the type that can be used in a deep oil well, although it is capable of other uses and other liquids. In the particular type of pump here involved, the pump motor is located at the bottom of the well and is adapted to be operated by hydraulic pressure in a power oil tube leading from the surface to the motor at the bottom of the well, which power oil tube is supplied with pressure substantially greater than the static hydraulic head, by suitable means on the surface.

The pump here involved has a double reciprocating piston in combination with a hydraulic motor designed automatically to produce the reciprocation of these pistons. To this end, it includes a reversing valve mechanism consisting of three valve elements, one of which does the actual reversing of the hydraulic connections to the motor, another of which controls the positioning of the first-mentioned valve, and still another of which controls the positioning of the second-mentioned valve. The third-mentioned valve is alternately contacted by members connected with the piston of the motor itself to effect reversal of the valve mechanism and consequent reversal of the pistons. One of the objects of the present invention is to prevent undue shock in certain operations of the last-named mechanism.

Another of the objects of the present invention is to provide a reversing valve mechanism that can be assembled with and disassembled from the other structures as a unit for servicing. An additional object is to provide a pump of this type in which assembly of the pump parts is not difficult and requires mainly a fitting together of successively arranged components with a single holding means for a large number of them and only a few holding means for the entire apparatus.

Other objects will appear from the description to follow.

In the drawings:

Figures 1 through 6 are successively lower parts of the pump mechanism in diametrical section occasionally broken away as at the upper end of Figure 3, and furthermore occasionally broken away to show parts other than those that would appear on the same diametrical cross section, and occasionally twisted about the pump axis;

Figure 7 is a transverse section on the line 7—7 of Figure 2;

Figure 8 is a vertical section on the diameter indicated at 8—8 in Figure 7;

Figure 9 is a transverse section on the line 9—9 of Figure 3;

Figure 10 is a developed view of the reversing valve mechanism;

Figure 11 is an elevational upper end view of a valve adapter included in the pump mechanism;

Figure 12 is a transverse section on the line 12—12 of Figure 6;

Figure 13 is a transverse section on the line 13—13 of Figure 6;

Figure 14 is a fragmentary vertical section on line 14—14 of Figure 11;

Figure 15 is a side elevation of one of the valve cages included in the pump mechanism;

Figure 16 is a bottom plan view of said cage; and

Figure 17 is an elevational lower end view of the valve body for the hydraulic reversing mechanism.

The present mechanism has been illustrated in well tubing 20, the spacing of which has been somewhat exaggerated for clarity of illustration. At the upper part of Figure 1 there is an elongated tubular fitting or adjusting sleeve 21 which is adapted to be connected to power oil tubes that lead to the surface to transmit power oil from the surface down to the pumping mechanism. One end of the sleeve 21 has an extended threaded area 22 below which there is a somewhat larger cylindrical portion 23. Below the cylindrical portion, the adjusting sleeve has an enlarged cylindrical flange 24. Below this there is a cylindrical plug-like portion having threads 25 and a cylindrical projection 26.

As noted by the dashed lines, the power oil passage 30 extends from the upper end of this member down through to the lower end. In the plug portion 26 it enlarges at 31 and has a flared portion 32 for a purpose later to appear.

The threaded portion 22 on the adjusting sleeve 21 receives an internally threaded skirt member 35 which has a function, later to appear, of directing the weight load of the parts to the outer barrel of the pump. There is also an externally threaded sleeve 34 that surrounds the cylindrical portion 23 of the adjusting sleeve 21, and which can abut against the flange 24 of that sleeve. The member 34, in turn, threads into the upper internally threaded end 36 of the upper part of the outer barrel 37. There is a locking ring 38 engageable with the threads 36 above the outer barrel 37; and, as appears in Figure 1, the skirted loading member 35 abuts the upper edge of the ring 38. The reason for these several parts will appear hereafter.

The lower end of the barrel 37, midway of the pump, is internally threaded at 39, and engages on an externally threaded upper end portion 40 of a valve mechanism body 41, these parts being shown in Figure 4. Details of the valve will later be given. The lower end of the valve body 41, however, is reduced and externally threaded at 42 similarly to the upper end, and receives the internally threaded upper end of a lower outer barrel part 43 which is similar to the upper barrel 37. This lower outer barrel 43 continues downwardly to the lower end of the pump mechanism as illustrated in Figures 5 and 6. At its bottom part it has an internally threaded portion 44 which is engageable over an externally threaded portion 45 of a union 46. These threaded portions are elongated to permit adjustment, although they are shown broken away and hence shortened in Figure 6, the externally threaded portion 45 of the fitting 46 being adjustable within the thread 44 for a purpose to appear. The fitting 46 is adapted to be attached to the pipe or other part that constitutes the intake for oil from the well, it having an intake passage 48.

The fitting 46 also has an internal vertical bore 49 that receives a cylindrical part 50 of a lower adjusting sleeve 51 that in some respects is similar to the upper adjusting sleeve 21. It has an enlarged flange 52 that is slidable within the lower outer barrel 43 and which provides a shoulder against which the upper end of the threaded portion 45 of the fitting 46 may engage. As is evident, the rotation of the fitting 46 by its hexagonal head will elevate or lower the sleeve 51. The sleeve has a bore 53 through it, the upper end of which is enlarged at 54 and flares out at 55.

The fitting 51 has a cylindrical upwardly projecting upper end in which the enlargement 54 and the flared

part 55 are disposed. The lower part of this upwardly projecting part is externally threaded at 56 adjacent the flange 52. The lower end of a valve adapter 58 is internally threaded so that it may engage over the threads 56 and fit tightly against the shoulder formed by the flanged part 52 of the fitting 51. There is a lock screw 59 that is threaded into the fitting 51 adjacent the threaded portion 56 and the flange portion 52. In order to receive the locking screw 59, the edge of the adapter 58 has one notch in it. By this means, these two parts may be threaded together and securely locked against coming unthreaded.

The valve adapter 58 is, generally speaking, cylindrical so that it can fit within the lower outer barrel 43, and it has sealing rings 61 therein for the purpose of sealing it within the barrel and separating off the portions of the barrel above and below these rings, save only for communication provided internally of the adapter 58. The upper part of the valve adapter 58 is not cylindrical. There are chordal flats 62 at the upper end, and opposite there is a longitudinal groove 63.

With reference also to Figure 11, the flats 62 are adapted to have inwardly extending passages 64 that enter the upper end of a valve receiving drill hole 64. This hole opens at its lower end into an enlarged recess 66 that receives the upper projecting end of the fitting 51.

There is a longitudinal passage 67 that is parallel to the valve receiving passage 65 and which can register with the flared part 55 of the opening 53 through the fitting 51 despite angular displacement between these parts, so that liquid may flow upwardly through these passages to above the valve adapter 58, whence it may also flow to the flats 62 and to the passages 64 to the upper end of the valve receiving bore 65.

The valve receiving bore 65 has three transverse outlet connections 70 that are illustrated in Figure 6 as being diametrically opposed, but this is only for purposes of simplicity. Actually, as illustrated in Figure 12, they are angularly disposed, and two of them straddle the passage 67. They are adapted to register with somewhat larger ports 71 through the outer barrel 43 that are large enough to permit some adjustment displacement of the adapter 58 in the barrel 43.

The bore 65 also has two intermediate radial outlets 73. These radial outlets connect into two longitudinal passages 74 on opposite sides of the passage 67. As shown in Figure 13, the two ports 73 are plugged at their outer ends. The two longitudinal passages 74 open upwardly toward the top of the valve adapter 58 and, at their upper ends, are connected by angular passages 76 opening into a top recess 77 as illustrated in Figure 11. The top ends of the passages 74 are plugged as at 75. The recess 77 opens into the lower pumping chamber wherein it is subjected alternately to high pressure and low pressure as the pump piston makes its strokes. In Figures 5 and 6, the passages are represented by a center line 75.

There are two check valves in the bore 65. They may be inserted from the lower end of this bore where it opens into the recess 66. Considering the order in which the parts are inserted, the first part is a valve seat ring 80 provided with a sealing ring, and which is inserted to the upper end of the bore 65. Next, there comes a dome-shaped valve head 81 operating within a four-legged valve cage 82, portrayed in Figures 15 and 16. The cage 82 has an upper ring 83 around its upper edge which fits over the depending central part of the valve seat 80 to aid in holding these parts together and in alignment. This bottom portion 84 of this cage has four arcuate recesses 85 around its edge so that liquid may flow downwardly past this bottom part 84. Four arcuately spaced legs 86 join the upper and lower rings 83 and 84 and act as valve guides. The center of the bottom part 84 has a hole 87 into which is pressed the lower shank of a plug 88.

A coil compression spring 89 surrounds the head of the plug 88 and also the corresponding medial part of the valve element 81, fitting into an annular recess in that valve part so that it is held properly in place.

Below the cage 82 there is a spacer 92, somewhat like a hollow cone, and which is provided with a passage 93 connecting through from the center of the bottom part of the spacer to the top part. As will be seen from Figure 6, the ports 73 within the valve adapter 58 connect into this space above the skirt of the cone member 92, beneath which there is another valve seat ring 96 which is similar to the valve seat ring 80. Below the ring 96 there is another check valve 97 within a cage 98, these parts being the same as the corresponding parts in the upper valve. A spring 99 urges the valve head 97 upwardly. The valve cage has the arcuate cut-outs 100 so that there can be flow through the bottom. Since these parts are identical, there is no need to describe the valve and cage more fully.

Below the cage 98 there is a plug member generally indicated at 102. It has an upper pin portion 103, an intermediate sealing ring receiving portion 104, and a bottom threaded portion 105. It is inserted into the lower part of the opening, and when the threads are interengaged, the sealing ring part will be in the position shown so it may be provided with an O-ring that seals the parts off, and the pin portion 103 will abut against the bottom of the cage 98. As a result, the threaded part 105 acts to hold all of the valve assembly in the bore 65.

The valve assembly is adapted to receive alternate high and low pressure on the ports 73 that open into the portion of bore 65 adjacent the spacer 92. When liquid under pressure is forced in through the port 73, it will pass upwardly against the underskirted portion of the valve 81 and drive it firmly against its seat 80. However, the pressure will also flow through the ports 93 of the spacer 92 to act on the dome-shaped part of the head of the valve 97, driving it away from the seat 96 and permitting the liquid to flow through the spaces between the legs of the cage and through the arcuate openings 100, whence it may flow outwardly through the lateral passages 70 and 71 to the space outside the outer barrel 43.

If a low pressure is drawn onto the port 73, the lower valve 97 will be drawn closed, but the upper valve 81 will be drawn open so that liquid flows in from the space adjacent the flats 62 through the passages 64, past the valve 81, and thence out through the passage 73. Since the passage 73 registers with the passage 74, the passage 76, and ultimately with the space 77, which appears at the bottom end of Figure 5 and also in Figure 14, it will be seen that the high and low liquid pressures above mentioned also exist in the recess 77. Liquid drawn into this space is drawn past the upper valve 81, and comes from the well liquid that flows upwardly from the inlet 48 at the bottom of the pump through the passage 67 and the space 63, to the flat area 62.

There is a connector 110 that has a reduced portion 111 snugly fitted into the recess 77, and an upper portion that sealingly engages within a pump cylinder 112 so that it constitutes a cylinder head. Suitable O-ring seals are provided as indicated in the lower part of Figure 5, where it is also seen that the lower end section of the pump cylinder 112 is eccentric of the outer barrel 43. The other parts of Figure 5 have the apparatus rotated about its axis so that the pump cylinder 112 appears to be axial of the outer barrel.

The lower pump cylinder 112 extends upwardly for a distance equal to the pump stroke, which may be several feet long. At its upper end it receives a fitting 113 which has a medial flange 114 with a lower portion that is snugly fitted into the upper part of the cylinder 112 with appropriate sealing rings, and an upper portion which similarly fits into a bore in a push rod and shifter adapter 115.

The cylinder **112** contains a lower piston **116**. This piston has a recess in its upper surface which receives a collar **117** that is threaded onto the lower end of a piston rod **118**. The piston rod is surrounded by another collar **119** that is threaded into the recess in the piston **116** so as to hold the piston rod removably within the piston. The parts are locked against coming apart by a lock screw **120**.

The fitting **113** slidably receives a shifter **121**. This shifter is cylindrical and hollow, as illustrated by the broken away portion in its middle, so that it can surround the connecting rod **118** with considerable space to spare, so that liquid being pumped may flow through this space. The outer surface of the shifter member **120** bears within the connector **113**, and this surface preferably is fluted as illustrated so as to reduce the chance of galling of this part when it reciprocates. The fluting also provides for limited flow of liquid around the outside of the shifter.

The upper end of the shifter **121** has an enlargement **122** that may fit down into a recess **123** in the upper end of the connecting fitting **113** so as to act as a dash pot for the reciprocation of this member.

At one side, the enlarged portion **122**, toward its top, has a lateral projection **125** for a purpose to appear. These parts all operate within an enlarged recess **126** within the push rod adapter **115**, which is more or less cylindrical so that it can be supported within the outer barrel **43**.

The lower portion of the push rod adapter is cylindrical but for a flat side part **130**. There is a slightly deeper flat part **131**, these being provided so that the flow of the well liquid upwardly to the side of the adapter **115** is not prevented. The chordal flat part **131** extends far enough across the adapter **115** to register with a pair of flat sides **132** and **133** (see Figure 9) on the opposite side of the adapter. These flat sides **132** and **133** extend up to adjacent the top of the adapter without change, and actually continue into the top of the adapter in a manner to permit the passage of liquid. By this means, the liquid can flow around the outside of the adapter **115**.

Internally, the adapter **115** has a longitudinal opening **136** through which the connecting rod **118** moves freely. It also has a passage **137** that connects into one side of the space **126** (see Figure 5) and extends to the top of the adapter. As is evident, this passage registers with the space inside the adapter and through the shifter **121**, which ultimately connects into the top surface of the piston **116**.

A third passage **138** extends through the adapter **115**, and it receives a reciprocating push rod **139**. This push rod **139** projects downwardly so that it may be engaged by the dog **125** on the shifter **121**. This push rod **139** has suitable bushings provided for it, and at its upper end there is a fitting **140** having sealing rings that project so they may engage in another part.

Above the adapter **115** there is a reversing valve body **142**. This body is part of the reversing valve mechanism **41**, and has its lower end threaded into the upper end of the lower barrel **43**, as has previously been described.

With reference also to Figure 17, this valve body **142**, as shown in the sectional view, has three ports **144**, **145** and **146** that extend from end to end of the valve body. These ports **144**, **145** and **146** are located so that they can register with the flat sides **132** and **133** on the surface of the adapter **115**. By this means, liquid flow moves past the adapter and through the valve body **142**.

In addition to the three ports described, the valve body **142** has a bore **147** that extends through it from end to end to receive a double-acting valve generally indicated at **148** and which is acted on by the push rod **139**. Details of this valve will be given later. There is another hole **149** that receives a pilot valve **150**. There is another opening **151** that receives a directional valve **152**.

The connecting rod **118** passes through a hole **153** in the valve body **142**. This hole is provided with a lining

sleeve **154** that is sealed into the hole **153** with appropriate sealing rings. The connecting rod **118** has a sliding fit within this sleeve **154** and seals therein.

The lower end of the valve body **142** also has a cylindrical passage **156** that extends part of the way up the valve body but terminates in a dead end having a lateral connection illustrated diagrammatically in dashed lines, and later to be described. There is a counterpart passage **157** opening down from the top of the valve body. The passage **156** connects with the space **137** in the adapter **115**. Finally, the valve body **142** has a power oil tube passage **158** that connects down from the top of the body about halfway through the body, and then terminates in lateral passages to be described.

Reference to Figure 4 will show that the fitting **140** projects into the opening **147** for a double-acting valve **148**. Similarly, there is a fitting **160** that fits within the fitting **115** and the opening **153** of the valve body **142**; and there is another fitting **161** that interfits with the passages **137** of the adapter **115**, and passage **156** of the valve body **142**.

By these fittings, which have close fits with sealing rings as indicated, the adapter **115** and the valve body are properly aligned in their only possible relationship as soon as they are fitted together by end pressure applied to the two of them.

Details of the valving arrangement will be described hereafter. Above the valve body **142** there is another adapter **170** which has a mirror relationship to the adapter **115** and functions in substantially the same way. It is not necessary to describe it in detail. Suffice it to say that it has a passage **171** that registers with the passage **157** of the valve body. It also has flats like the flats **132** and **133** previously described so that liquid may be conducted up outside of it from the holes through the valve body **142**. Actually, Figure 9 is a view of the flats of the upper adapter **170** rather than those on the lower adapter, but since they are mirror copies of each other, either description will suffice. The adapter supports a push rod **175** that corresponds to the push rod **139** and contacts upon the valve **148**. There is also a connector **177** that corresponds to the lower connector **113**. It receives a shifter **178** like the shifter **121**. The shifter **178** has a dog **179** for acuating the push rod **175**. The shifter **178** is shown as projecting upwardly because it will be forced upwardly by the action of the lower piston. It is projecting into the path of the upper piston, as will appear.

The connector **177** has an upwardly projecting portion that receives an upper pump cylinder **180**, and the upper end of the cylinder **180** is closed by a connector member **181**, all with appropriate sealing rings as illustrated.

The connecting rod **118** passes through the foregoing parts as will be understood, and it has at its upper end an upper piston **183**.

The connector **181** at the top of the upper cylinder **180** connects into a valve adapter **183** that is identical with the lower valve adapter **58**, although turned upside down, and connected slightly differently, as will appear.

There is a passage **182** through the connector **181**, and this opens into a passage **184** in the valve adapter **183**. The passage **184** then connects into a passage **185**. There are two of these passages **185** similarly connected, and they correspond to the passages **74** in the lower adapter. They, in turn, connect by radial passages into a valve receiving bore **186**. Figure 7 shows that there are two such passages **185**, they being plugged up at their lower ends as illustrated in Figure 2. In addition, there is a passage **187** between the two passages **185** which is a power liquid passage. It is connected through a fitting **188** with a pipe **189** that connects into a recess in the top part of the valve body **142** so that it may connect into the power liquid passage **158** in that valve body.

The adapter **183** also has a flat portion **191** on the lower part thereof at one side so that liquid may flow

up around the lower part of the valve body and into the passage **192** that opens into the bottom of the valve receiving bore **186**.

There are check valves within the bore **186** that are, for all practical purposes, identical with the two lower check valves **81** and **97** with their assemblies. Thus, there is a lower valve seat ring **193**, a lower valve cage **194**, and a lower valve **195** that is spring urged downwardly. Arcuate recesses **196** can permit the flow of liquid around the head and the legs of the cage to the space above the cage when the valve is open. Above the valve there is a spacer **197** which is similar to the one previously described. It will be observed that the passages **185** open into the space around this spacer. Above the spacer there is another valve seat ring **198** onto which a valve **199** may seat. This valve **199** is within a valve cage **200** and is spring urged downwardly. The cage **200** is held in place by a pin **201** of a plug member **202** which has a threaded portion and a sealing ring portion as previously described. The plug member may be threaded into place so as to hold the valve parts in place after they have been inserted through the upper end of the bore **186**.

The upper end of the valve adapter **183** has three lateral passages **205** that correspond to the ones of the lower check valve assembly. They register with ports **206** that are slightly larger and permit oil to move outwardly of the barrel **37**.

The parts above the foregoing have already been described. The adjusting sleeve **23** is secured into the valve adapter **183**, and the threaded sleeve **34** binds the parts tightly together in the barrel **37**. It is to be noted that Figure 8 illustrates how the passage **187** for power liquid extends upwardly through the adapter **183**, so as to open into the flared part **32** of the opening **30** that extends axially through the member **23**.

From the description thus far, it can be determined that when the pump is inserted into a well liquid such as oil (and the description hereafter will suppose oil is the liquid being pumped) may flow up through the inlet **48** into the fitting **50** and the inlet **53**, thence up through the passage **67** above the lower valve adapter **58**. It also may thereafter flow up outside the lower pumping cylinder **112** but within the lower barrel **43**. Owing to the outer configuration of the push rod adapter **115**, this oil may flow around the outside of that adapter which begins at the top of Figure 5 and continues upwardly in Figure 4. At the top of the adapter **115**, the oil may move through the three holes **144–146** through the valve body **142** of the reversing valve mechanism **41**. At the top of this valve body, the oil may again flow past the upper push rod adapter **170** the same way it flowed past the lower one. Above this adapter it flows outside of the upper pumping cylinder **180** to the lower part of the upper valve adapter **183**. At this point, it may flow only around the lower part of this adapter at **191** and thence through the port **192** to the space below the lower check valve **195** of this upper set of check valves. If this valve is closed, the inflow stops at that point.

Meanwhile, there is production oil that has previously been pumped into the tubing **20** outside of the pump barrels. This oil will have been pumped out through the upper passages **206** leading to the space above the upper check valves and also through the lower ports **71** that lead to the space below the lowest check valve of the lower set.

In addition, power oil comes down from a pipe connected into the member **21** and is conducted by that member downwardly to the passage **187** in the upper valve adapter **183**, and thence by a pipe **189** into the valve body **142**.

It should be clear that when the pistons are moved downwardly well oil will be drawn inwardly through the passages **191** and **192** to open the valve **195**, and thence to flow through the passages **185**, **184** and **182** into the upper cylinder above the piston **183**. At the same time, oil previously drawn in like manner into the lower pump cylinder below the lower piston **116** will be forced outwardly through the fitting **110**, and thence, by way of the two passages **76** and **74** and their passages **73**, to the space above the check valve **97**. This being the compression stroke, that valve **97** will be forced open and the oil will flow past through the notches **100** into the spaces **70** and **71**, whence it will be discharged into the production oil space outside of the barrel

In like manner, when the pistons reverse themselves and move upwardly, the oil previously drawn into the upper cylinder will be expelled past the upper check valve **199** of the upper set, and thence out through the passages **205** and **206** into the production oil space. At the same time, new well oil will be drawn inwardly from the spaces **63** and **62**, past the check valve **81**, and thence through the port **73** and into the lower cylinder below the lower piston **116**.

The pistons are driven by power oil acting on their inner or adjacent surfaces (it is for obvious reasons better to have the power oil operating on the inner or adjacent surfaces of the two pistons rather than their outer surfaces, and rather than employing one piston solely as the motor piston and the other solely as the pump piston, since this simplifies control. However, if the simplicity of control is not a problem, this could be reversed). For convenience, the adjacent power oil portions of the cylinders and pistons may be referred to as pump motor parts, and the other remote portions of these same elements may be referred to as the pump parts.

The hydraulic reversing mechanism is disposed within the valve body **142** and is shown in a development in Figure 10.

In Figure 10, the power oil tube is generally indicated at **189**. However, owing to the fact that there is a very large power oil passage leading to the directional valve **152** and relatively small passages leading to the two other valves, Figure 10 illustrates at **189***a* a smaller passage which actually is only a smaller part of the power oil passage **189**.

Inspection of Figure 10 will show that the power oil is always conducted to the middle of all of the three valves so that it is always available at each valve.

The directional valve **148** has two lands providing a single valve passage **210**. Beyond the lands forming the passage **210** it has upper and lower flanges **211** and **212** that form abutment means.

The middle part of the hole that receives the valve **148** is provided with a cylindrical sleeve **212**. Above the abutment **211** the valve rod is reduced and is surrounded first by a washer **213**, then by a coil spring **214**, and finally by another washer **215** that abuts against an upper fitting **216** in the valve body **142** or an enlarged head **217** on the valve.

In similar fashion, the lower part of the valve stem is reduced and is surrounded by a washer **218**, a spring **219**, and another washer **220**. Below the washer **220**, the valve stem is enlarged at **221** similar to the enlargement **217**.

With the foregoing arrangement, the extremes of movement of the valve **148**, beyond neutral position in which the valve passage **210** is in a middle position, are cushioned. Figure 10 illustrates the valve in an upper position because the pistons are up and the lower actuator **121** is acted upon by the push rod **139** to push the valve to an upper position. In this action, the lower enlargement **221** on the valve stem acts against the washer **220** compressing the spring **219**, while the upper end of the spring is held by the engagement of the washer **218** against the sleeve **212**. Meanwhile, also, the upper abutment **211** has caused some displacement of the washer **213** and some compression of the spring **214** while its upper end is held by the abutment of the washer **215** against the fitting **216**.

When the valve is in its upper position illustrated,

the power oil line **189***a* is connected by way of the valve passage **210** to a valve passage **230** that connects into the hydraulic pressure chamber at the left end of the pilot valve **150**, so that this power oil tends to move the pilot valve upwardly. Meanwhile, the other end of the pilot valve is ported through a compound port **231** to the space beyond the abutment **212** on the valve **148**, whence it may exhaust by way of a passage **232** that leads to the production oil space outside of the pump. If this double-acting valve **148** is moved downwardly, the foregoing connections are just reversed and the pilot valve will be moved downwardly by connecting power oil into its upper operating chamber and opening the lower chamber to exhaust by a port **233**. As soon as the shifter devices and push rods are released by movement of the piston a short distance away from its extreme position, the two springs **214** will neutralize the double-acting valve to a position at which the two lands cover the two ports **230** and **231**, and a hydraulic lock is provided for the pilot valve **150**.

The pilot valve has four lands and three valve spaces **235**, **236** and **237**. Power oil is always introduced by the passage **189***a* into the middle pilot valve passage **236**. This valve is illustrated in its upper position so that the space **236** connects into a compound port **240** that leads into an upper hydraulic pressure chamber for the directional valve **152**. Meanwhile, the lower pressure chamber of the directional valve **152** is connected by another compound passage **241** to the valve passage **237**, whence it is connected by a passage **242** to exhaust into the production oil space.

If the pilot valve is reversed, the foregoing connections are reversed, in which event the power oil is supplied to the passage **241** into the lower pressure chamber of the directional valve to elevate the same, while the upper directional valve pressure chamber connects through the passage **241**, which at this point connects through the valve passage **237** of the pilot valve to an exhaust passage **244**.

The directional valve **152** is mounted within a sleeve **245** that is within the directional valve bore through the valve body **142**. The opposite ends of the bore are plugged, as illustrated.

The directional valve has four lands and three valve passages **246**, **247** and **248**. The large power oil line **189** connects directly to the middle of the directional valve, the sleeve providing a constant porting of this oil into the valve space **247**. As illustrated, this valve is in a lower position and consequently the passage **247** connects the power oil to the passage **156**, which at this point is connected by way of the passage **137** in the adapter **115** so as to lead ultimately into the cylinder above the lower piston **116**, where it may draw that piston downwardly because of the high pressure supplied to the power oil from appropriate means at the surface.

In the meanwhile, the space beneath the upper piston **183** is connected to the passage **171** and the passage **157** in the valve body which, as illustrated, is connected into the upper passage **246** of the directional valve. This upper passage **246** connects with an exhaust passage **250** when the directional valve is in the position shown.

If the directional valve reverses its position, as it will if the double-acting valve is driven downwardly, which in turn causes the pilot valve to be driven downwardly and the directional valve to be driven upwardly—then the valve space **247** of the directional valve will connect the power oil passage **189** with the line **157** leading to the space beneath the upper piston, and at the same time the space above the lower piston will be connected to exhaust by the valve passage **248** connecting to an exhaust outlet **252**.

Operation

It has already been pointed out how the oil from the well is drawn into the two pumping cylinders (which are the remote cylinders above the upper piston and below the lower piston) and is forced out by them as they reciprocate. This, in general, is conventional, although the way it is performed and the arrangement of the parts here is different in certain respects. The driving of the pistons up and down is attained by the alternate connection of the power cylinders (which are the adjacent cylinders below the upper piston and above the lower piston) to power oil and exhaust, respectively, and vice versa.

As each piston approaches the valve body **142**, it will strike the shifter **121** or **178**, as the case may be. Assuming that it strikes the shifter **121** as the piston **116** has already done in the views given, it will drive the shifter **121** upwardly in contact with the push rod **139**, and that push rod, in turn, will drive the double-acting valve upwardly. In Figure 10, this has already occurred and has caused the pilot valve to shift, and this, in turn, has caused the directional valve to shift to the lower positions, so that power oil is directed to the top of the piston **183** to drive the same downwardly.

The upper piston **183**, as it reaches the lowest part of its travel, will strike the shifter **178** which, in turn, will strike the push rod **175** to move the double-acting valve **148** downwardly, and this will cause the pilot valve to move downwardly and the directional valve to move upwardly. Thereupon, the power oil which formerly had been directed to the space above the lower piston **116** will then be directed to the space below the upper piston **183**. Such power oil as had just been forced into the lower power cylinder, to drive the pistons downwardly, will then be forced outwardly and will join the production oil in the space outside of the pump barrel. Thus, the pump motor operates the pump to drive oil to the surface.

One of the features of the present invention is that the shifting of the valve parts is done without severe shock thereto. The valve actuator **121** has a dash pot arrangement in the fit of the collar **122** into the annular space **123**, with the fluting governing the rate at which the movement of the actuator is retarded. The other actuator is similarly dampened. The double-acting valve **148** is cushioned at the ends of its movements by the springs **214** and **219**. By these arrangements, the parts are cushioned against sudden stops when subjected to abrupt pressure changes, such as may result from reversal of the hydraulic pressure conditions surrounding the actuators and the valve.

Assembly

One of the particular features of the present pump is its manner of assembly. The valve body **142** can be a starting point for the assembly. It is pre-assembled with its several components including the valves and the associated parts. Conveniently, the connecting rod **118** may be passed through the valve body.

The lower adapter **115** is then connected with the valve body by pressing these parts together over the fittings **140**, **160** and **161**, which automatically align the adapter and the valve body, and also provide the appropriate seals between these several passages.

The push rod **139** is located within the adapter **115** and the shifter **121** is disposed over the connecting rod **118**. The shifter is inserted through the bottom opening of the push rod adapter **115**, which opening is large enough to permit the passage of the head of the shifter element. When the shifter is thus inserted into the adapter, the connector fitting **113** may be applied over the shifter and may be inserted into place within the adapter **115**. Then the piston may be assembled on the end of the connecting rod **118**, and the cylinder **112** located over the piston.

The lower end of the cylinder **112** receives the fitting **110** onto which is pressed the lower valve adapter **58**, which is also fitted into the lower outer barrel **43**. The valves will previously have been assembled into this valve adapter **58**.

Then the connector **51** is threaded into the lower end

of the valve adapter 58, and when tight and in proper alignment the lock screw 59 is secured in place. All of the foregoing parts have stability when strung together because of the elongated interfitting parts such as the connector 113.

The outer barrel is fitted over the foregoing parts and tightened onto the valve body 142. Then the lower adjustment sleeve 46 is fitted over the projection 50 and threaded into the barrel 43 so that it will drive the aligned parts tightly together so that they are held there. In this tightening action of the fitting 46, its bearing onto the connector 52 cannot produce any twisting action on the threads between the connector and the valve adapter 58 because of the lock screw 59. There is a substantial excess of length of threads on the fitting 46 over those on the outer barrel 43 so as to provide ample adjustment at this point.

The foregoing secures the lower parts together. The upper parts are assembled in a similar manner. The upper adapter 170 is fitted onto the upper end of the valve body and is located and held by the interengaging fittings corresponding to the fittings 140, 160 and 161 that were previously described. Then the connector or shifter guide 177 is interfitted after the appropriate introduction of the upper shifter 178 in the manner that should be clear. Thereupon, the upper cylinder 180 is located over the guide 177, the upper piston 183 having been previously assembled onto the connecting rod 118. After this the upper closure 181 for the upper cylinder is located in place and the valve adapter 183 secured thereon with its valves previously located in their proper places. The upper member 23 is threaded into place in the adapter 183 and locked by the lock screw in a manner similar to the lower connections. Then the upper outer barrel 37 is located over the foregoing parts and is threaded onto the sleeve 34. This sleeve may be withdrawn a suitable distance to permit the free connection of the upper barrel 37 onto the valve body 142, after which the sleeve 34 may be tightened down to force the intervening parts snugly together. Then the locking ring 38 may be turned tight so as to lock these parts in the positions indicated.

The connections thus far hold the pump parts together, and it will be seen that it requires only a minimum of threaded connections to be loosened for ready disassembly of these parts for servicing.

The power oil connector 21 is connected into piping that leads to the surface and it carries a full head of power oil. Consequently, when the pump is at the bottom of the well there is a very heavy load on this piping. Yet this load could be conducted to the aligned parts within the barrel unless provision were made to distribute it otherwise. Such means is formed by the skirted body 35 which is threaded onto the threads 22 with a part of the power oil tubing. This member 35 is turned onto these threads so that it bears tightly above the locking ring 38, and finally the lock nut above it may be tightened down.

With this arrangement, when the load of the power oil tubing acts downwardly, it is conveyed through the skirted member 35 and the ring 38 to the barrel 37, and thence downwardly to the bottom of the well, which relieves the strain on the operating internal parts of the mechanism.

What is claimed is:

1. In a pump motor apparatus, a liquid inlet for liquid to be pumped from the supply; a lower cylinder and an upper cylinder; a reversing valve mechanism between the cylinders to which each is attached; a pair of pistons, one in each cylinder, the pistons being connected by a connecting rod that is removably attached to at least one of the pistons, the cylinders and pistons providing two opposed piston faces, and said cylinders providing opposed pump motor pistons, the reversing valve mechanism including a shiftable valve alternately to port the respective pump motor pistons to power fluid so that the pistons may be reciprocated back and forth, and including a single shiftable valve with a multiplicity of longitudinally reciprocable projecting means adapted to be operated by each piston as it approaches an extreme of its stroke, to cause the reversal of the reversing valve mechanism to be effected.

2. In a pump motor apparatus, a liquid inlet for liquid to be pumped from the supply; a lower cylinder and an upper cylinder; a reversing valve mechanism between the cylinders to which each is attached; a pair of pistons, one in each cylinder, the pistons being connected by a connecting rod that is removably attached to at least one of the pistons, the cylinders and pistons providing two opposed piston faces, and said cylinders providing opposed pump motor pistons, the reversing valve mechanism including a shiftable valve alternately to port the respective pump motor pistons to power fluid so that the pistons may be reciprocated back and forth, and including a single shiftable valve with a multiplicity of longitudinally reciprocable projecting means adapted to be operated by each piston as it approaches an extreme of its stroke, to cause the reversal of the reversing valve mechanism to be effected; upper and lower barrels removably attached oppositely to the reversing valve mechanism; and means removably to support the two cylinders in the respective barrels, the two cylinders being separately detachable from the reversing valve mechanism so the latter may be removed from the pump motor apparatus when the removable piston is also disconnected to free the valve mechanism from the connecting rod, and the barrels and cylinders are disconnected from it.

3. A pump motor including upper and lower cylinders and a reversing valve mechanism connected between them and joining them; a pair of connected pistons, one in each cylinder, the reversing valve mechanism including reciprocating means with an end projecting into each cylinder to be engaged and displaced by the corresponding piston as it reaches the end of its stroke, and including mechanism operated by such displacements to port power fluid under pressure into the cylinder of which the piston has so reached the end of its stroke to drive the piston in the opposite direction and to relieve such pressure in the other cylinder; and means to cushion the displacements of the reciprocating means.

4. A pump motor including upper and lower cylinders and a reversing valve mechanism connected between them and joining them; a pair of connected pistons, one in each cylinder, the reversing valve mechanism including reciprocating means with an end projecting into each cylinder to be engaged and displaced by the corresponding piston as it reaches the end of its stroke, and including mechanism operated by such displacements to port power fluid under pressure into the cylinder of which the piston has so reached the end of its stroke, to drive the piston in the opposite direction and to relieve such pressure in the other cylinder; and means to cushion the displacements of the reciprocating means, the reciprocating means having end surfaces exposed to the pressures within the cylinders so that they are driven from the cylinder subjected to the power fluid and toward that relieved of such power fluid pressure, and the cushioning means being disposed to cushion movements of the reciprocating members when driven from the cylinder when power fluid pressure is ported thereto by reversal of the reversing valve mechanism.

5. The combination of claim 4, wherein the cushioning means comprises spring means engageable at the end of the stroke of the reciprocating means.

6. The combination of claim 4, wherein the cushioning means includes dashpot means engageable at the end of the stroke of the reciprocating means.

7. In a pump motor apparatus, a cylinder device; a piston device operating therein having opposite faces in opposite cylinder parts adapted to be subjected alterna-

tively to a power fluid under pressure, to operate the piston device back and forth; a reversing valve mechanism having projections entering each cylinder part and subjected to the fluid pressures therein, and located to be displaced as each piston face moves in the extreme of its stroke, and the reversing valve mechanism including means responsive to the movement of each projection to port power fluid into its cylinder part and to relieve the pressure in the other cylinder part, such high pressure acting to drive the projection an additional distance in the direction it has been moved by the piston; and cushioning means to cushion movements for said additional distances.

8. The combination of claim 7, wherein the reciprocating means includes a rod-like element and the cushioning means includes springs oppositely engageable by the rod-like element.

9. The combination of claim 7, wherein the reciprocating means includes a rod-like element, and slidable shifter elements, one at each opposite end of the element, each shifter element being engageable at one end with the rod-like element and at its other end projecting into an adjacent cylinder to be engaged by the piston therein, and being subjected to the pressures existing in its adjacent cylinder, bearing means surrounding each shifter and supporting it for reciprocation; and the cushioning means including dashpot means to restrain movements of each shifter element in the direction toward its adjacent piston.

10. The combination of claim 1, wherein there are upper and lower barrels oppositely connected removably to the reversing valve mechanism; an inlet fitting on the lower end of the lower barrel; a lower check valve assembly in the lower barrel, connected to the lower end of the lower cylinder; a power oil connection fitting at the upper end of the upper barrel; an upper check valve assembly in the upper barrel and connected between the fitting and the upper cylinder, each check valve assembly having two oppositely acting check valves, having a passage connecting the adjacent cylinder between them, having a passage connecting the opposite side of one check valve to outside the barrel, and having another passage connecting the opposite side of the other check valve to the space between the barrel and the cylinder.

11. In a pump motor apparatus, a liquid inlet for liquid to be pumped from the supply; a lower cylinder and an upper cylinder; a reversing valve mechanism between the cylinders to which each is attached; a pair of pistons, one in each cylinder, the pistons being connected by a connecting rod that is removably attached to at least one of the pistons, the cylinders and pistons providing two opposed piston faces, and said cylinders providing opposed pump motor pistons, an upper barrel surrounding the cylinder and removably connected at its lower end to the reversing valve mechanism, an abutting plug-and-socket connection means between the cylinder and the reversing valve mechanism adapted to close the down end of the cylinder but to permit the connecting rod to pass therethrough, the connection means being removable from the cylinder by axial withdrawal therefrom, another abutting plug-and-socket connection means to close the upper end of the cylinder, the means being removable from the upper end of the cylinder by axial withdrawal therefrom, and a device adjustably secured to the upper end of the barrel with a cam-like connection, the device being engageable against the upper end of the other connection means to apply clamping force thereto, and through the other abutting parts, to the reversing valve mechanism.

12. In a pump motor apparatus, a liquid inlet for liquid to be pumped from the supply; a lower cylinder and an upper cylinder; a reversing valve mechanism between the cylinders to which each is attached; a pair of pistons, one in each cylinder, the pistons being connected by a connecting rod that is removably attached to at least one of the pistons, the cylinders and pistons providing two opposed piston faces, and said cylinders providing opposed pump motor pistons, a lower barrel surrounding the lower cylinder and removably connected at its upper end to the reversing valve mechanism, an abutting plug-and-socket connection means between the lower cylinder and the reversing valve mechanism, adapted to close the upper end of the cylinder but to permit the connecting rod to pass therethrough, the connection means being removable from the cylinder by axial withdrawal therefrom; another abutting plug-and-socket connection means to close the lower end of the cylinder, the means being removable from the lower end of the cylinder by axial withdrawal therefrom, and a device adjustably secured to the lower end of the barrel with a cam-like connection, the device being engageable against the lower end of the other connection means to apply a clamping force thereto, and through the other abutting parts, to the reversing valve mechanism.

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