May 2, 1939. J. D. MATHEWS 2,156,537

FLUID DRIVEN MOTOR PUMP

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Fig. 1

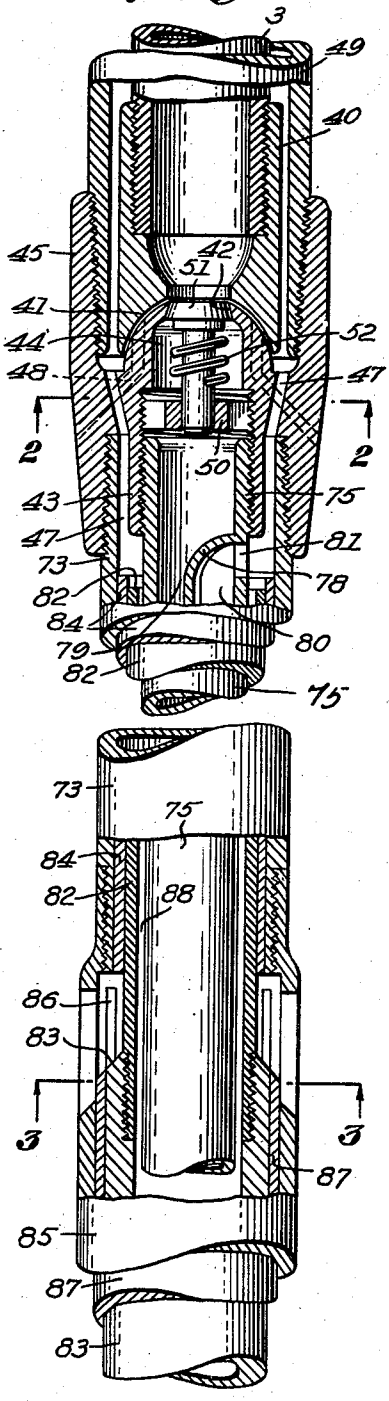


Fig. 2

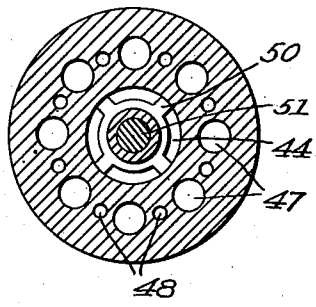
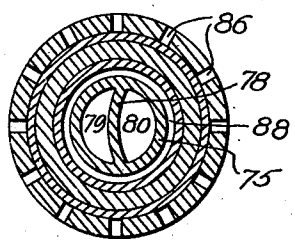


Fig. 3



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FIG. 4

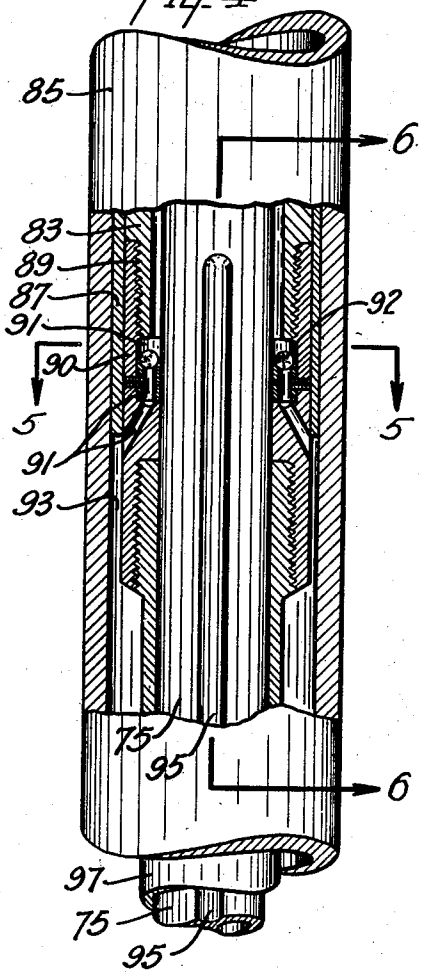


FIG. 6

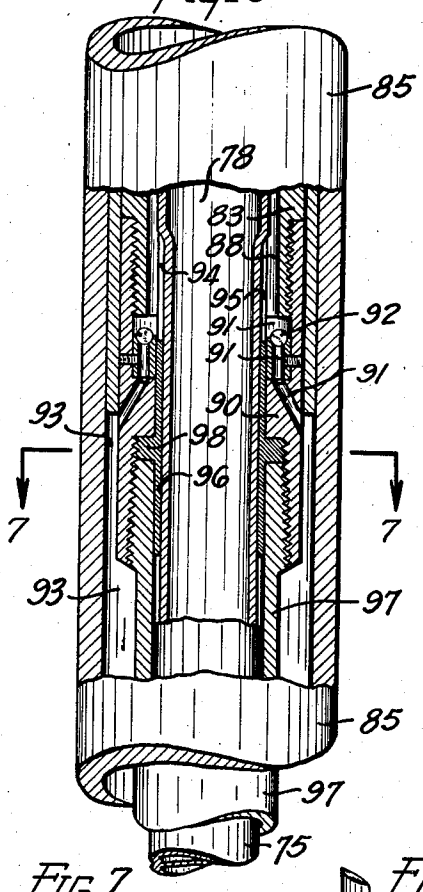


FIG. 5

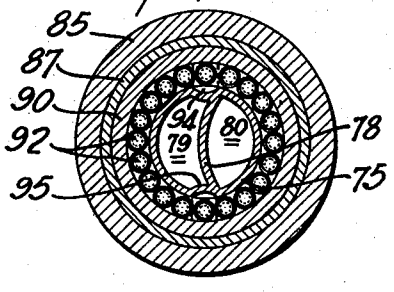


FIG. 7

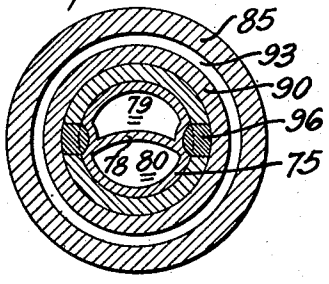
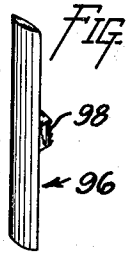


FIG. 8



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FIG. 9

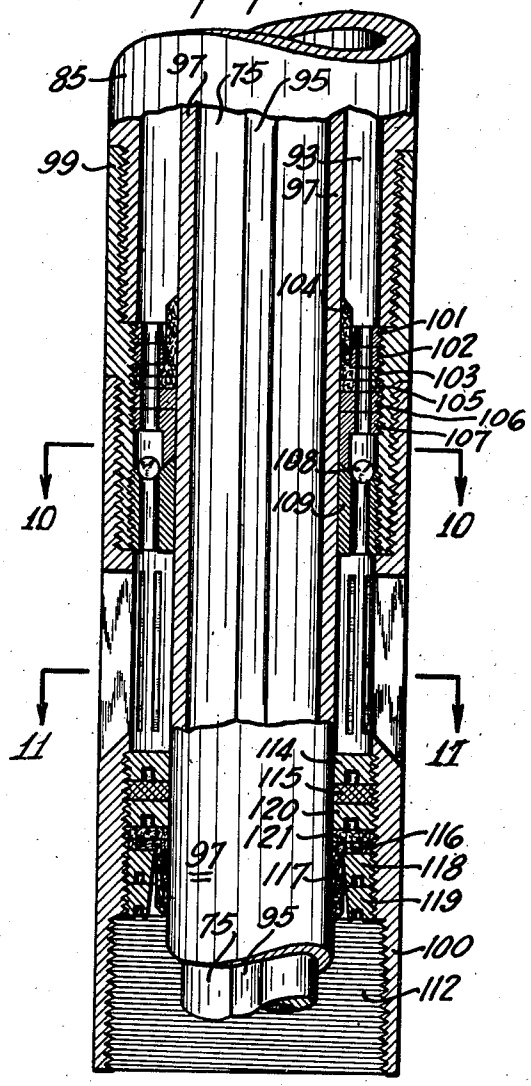


FIG. 10

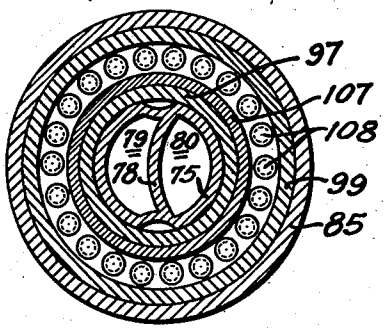
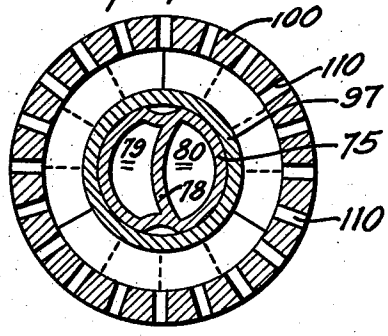


FIG. 11



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FLUID DRIVEN MOTOR PUMP

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FIG. 12

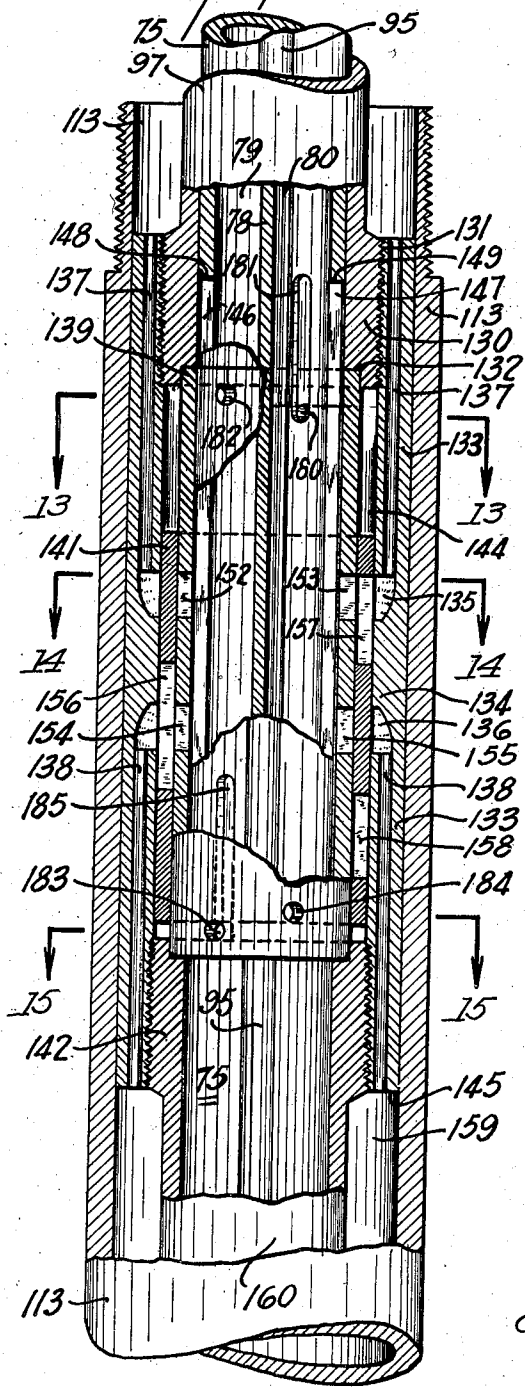


FIG. 13

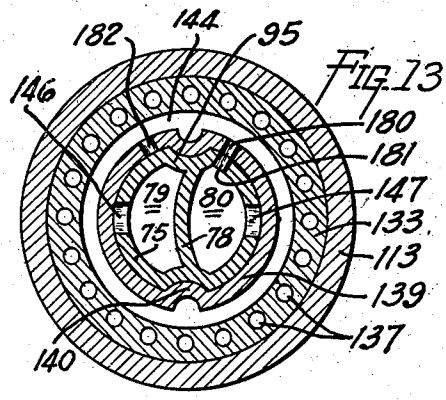


FIG. 14

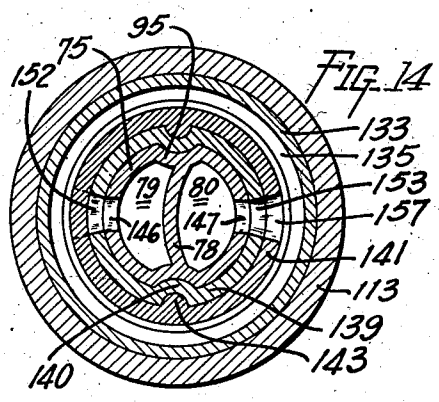
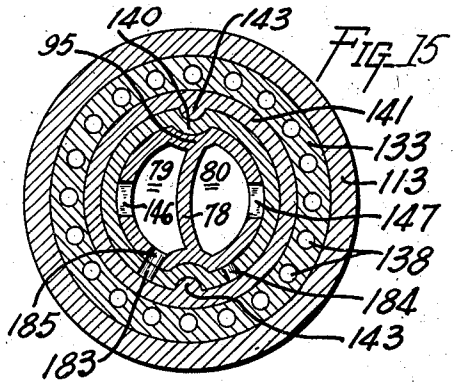


FIG. 15



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FLUID DRIVEN MOTOR PUMP

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FIG. 16

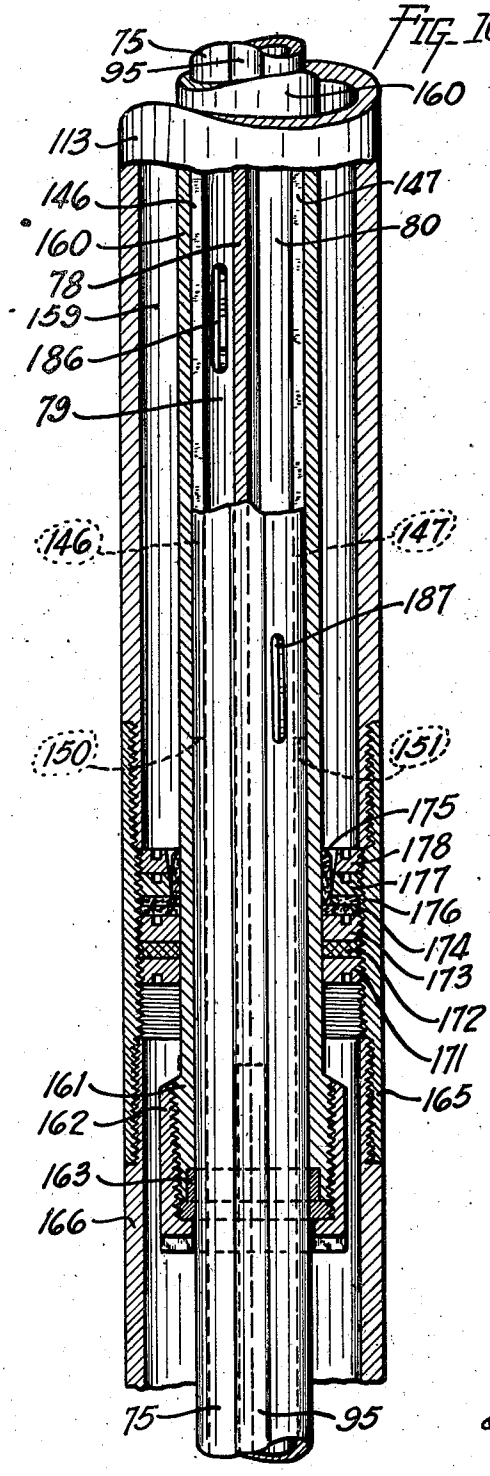
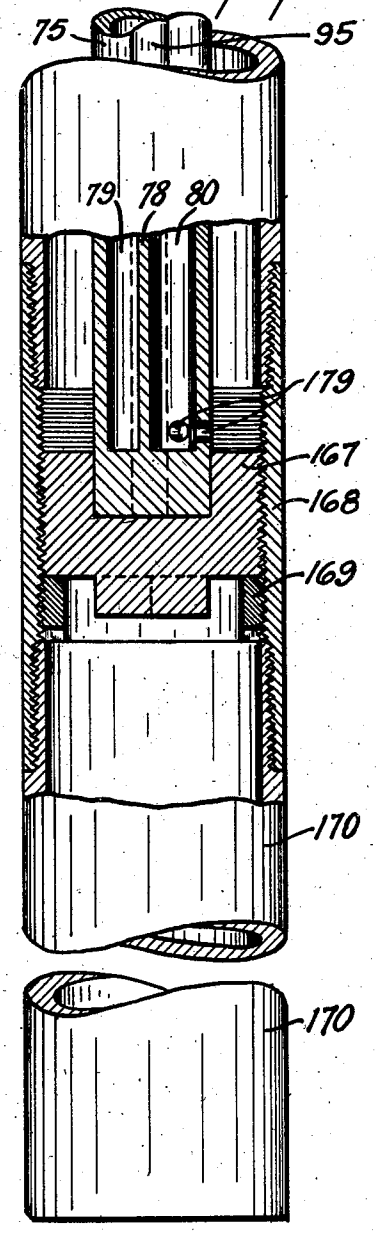


FIG. 17



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FLUID DRIVEN MOTOR PUMP

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FIG. 18

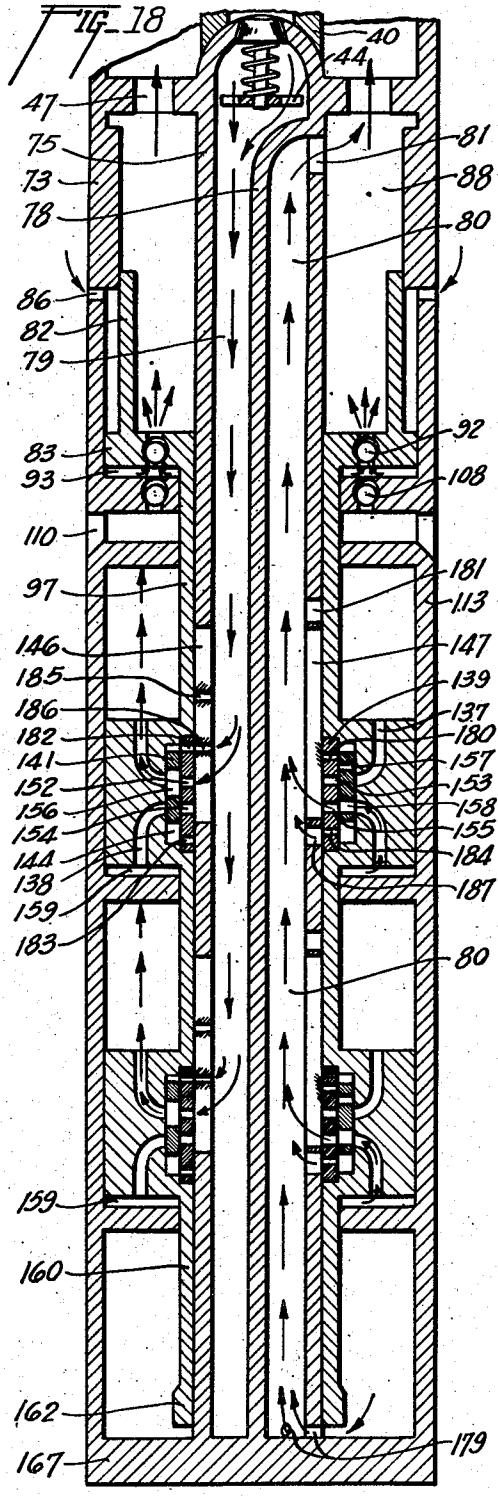
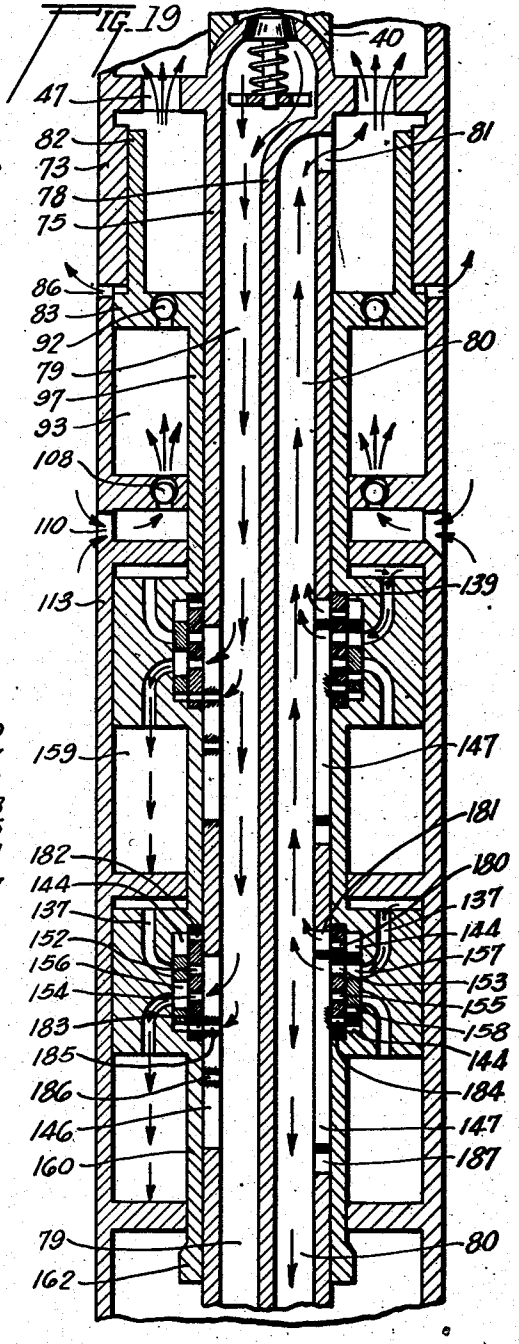


FIG. 19



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Patented May 2, 1939 2,156,537

UNITED STATES PATENT OFFICE

2,156,537

FLUID DRIVEN MOTOR PUMP

John D. Mathews, Oklahoma City, Okla.

Application August 15, 1935, Serial No. 36,383

26 Claims. (Cl. 103—46)

My invention relates to fluid driven motor-pumps, and more particularly to such pumps for use in lifting liquids from bored wells.

At the present time motor-pumps for this purpose require a power unit upon the earth's surface for delivering a fluid under pressure through a tube or pipe line to the motor situated within the well.

The usual motor comprises substantially: a piston head and rod reciprocatably mounted within a barrel and having upper and lower faces which oppose respectively an upper and lower cylinder head within the barrel; valve means for delivering the power fluid to within the barrel alternately above and below the piston head; valve means for exhausting used power fluid alternately from within the barrel below and above the piston head in timed relation to the delivery of the power fluid; and a motor exhaust conduit into a production tubing or above a packer into the casing. The usual pump associated with and actuated by the motor comprises: a working barrel, a piston reciprocatably mounted therein and connected to the motor piston head by a piston rod; suitable valved intake and discharge ports for production fluid; and, a pump discharge conduit leading into production tubing or into the well casing above a packer.

Insofar as I have been able to learn there has never been applied in fluid driven motor pumps a principle permitting total motor piston area of more than a fraction of the total cross sectional area of the casing bore. This limit has necessitated the use of excessively high pressures for actuating even very small pumps.

Other obstacles to be met vary between the motor pumps driven by a gaseous fluid and those driven by a liquid.

In motor-pumps using a liquid as a power fluid great difficulty has been encountered in valving the long moving columns of the liquid. When the columns are valved in a usual manner, such great pressures are developed by stoppage of the moving columns at each stroke that, in order to prevent bursting, the motor-pump must be operated at low velocities in comparison with usual pump practice, thereby limiting sharply the quantity which can be pumped, more particularly from deep wells.

Due to the difficulties of valving and water hammer encountered in using liquid as a power fluid for fluid driven motor-pumps, many designers and inventors have resorted to the use of a gaseous power fluid, even though the readily compressible nature of such fluid together with the high pressures under which it must be placed require extremely large volume and consequently expensive power generating equipment at the earth's surface, which entails high operating cost.

My motor-pump eliminates the difficulties enumerated in both types of fluid driven motor-pumps, accomplishes quantity production, and operates upon a power fluid delivered at an optional pressure approximating one half to even one tenth the usual required pressures.

Some objects of the invention are to provide a device of this class which includes an interacting, unitary, fluid operated motor-pump capable of raising liquids from much greater depths than heretofore possible with devices of this type, due to a novel method of amplification of the ratio of power piston areas to pump piston areas; which will eliminate shock or "water hammer", when liquid is used as a power fluid, by a novel valving principle and mechanism; which embodies a new and novel method of power fluid delivery and exhaust disposal particularly suited to simplicity in the application of my principle of selective piston ratio amplification; which is capable of operation under all known well conditions, in either deep or shallow wells; which may be positioned and sealed in a well without use of a packer; which is capable of installation in wells in such a manner as to provide means for excess gas pressure disposal and for maintenance of desirable gas pressure in the well when such pressure is present; and, which includes means for preventing the entry of foreign substances into the working mechanism.

Other objects of the invention are to provide a device of this class which is new, novel, practical and of utility; which may be lowered into a well upon production tubing surrounding a fluid power delivery tube, so that thereafter, the delivery tube may be removed from the well to permit cleaning of the production tubing without affecting the device; which, upon receiving a supply of power fluid, will start from any point in the cycle of the motor; which includes a fluid means for stopping and preventing injury to the valve at each end of its stroke; which may have a constant useful motor piston area in each end of the piston chamber; which may be operated at high speed even in extremely deep wells; and, which will be efficient in accomplishing all the purposes for which it is intended.

Heretofore, in fluid driven unitary motor-pumps in wells, the working area of the motor piston has been restricted to considerably less than the cross sectional area of the well casing,

consequently entailing excessively high pressures of motive fluid in the above ground pump or compressor, in the power fluid conveying line, and in the motor-pump at the bottom of the well, particularly in deep wells, thus limiting sharply the amount of liquid possible to be delivered by the pump. The limit which the present dimension of the well casing places upon the size of the motor piston, together with the highest practical pressure at which the power fluid can be delivered, combine to set an absolute limit upon the depth at which a pump of given capacity can be operated practically.

My invention provides an efficient fluid driven motor-pump which produces novel results through use of a new principle for the selective amplification of the working area of the motor piston far beyond the limit set by the size of the well casing.

My method generally, includes the use of a combination of a vertical series of co-acting motor piston faces and chambers, with means for supply, control, and exhaust of power fluid. Specifically, for a given pump piston area with power fluid delivered to the motor at the highest practical pressure, by multiplying the motor piston area, I multiply the force which can be exerted on a pump of given size, therefore multiplying the depth at which the motor-pump will operate.

In comparison with present fluid driven motor-pumps operating at the same depth, by doubling or tripling the useful motor piston area, my motor-pump can operate upon the same power fluid pressure, and the size of the pump piston can be doubled or tripled, thus doubling or tripling the volume of well fluid delivered to the earth's surface. Or, in operating a pump piston of a size and at a depth the same as those of present fluid driven motor-pumps, I can, by doubling or tripling the working area of the motor piston, operate my motor-pump upon one-half or one-third of the power fluid pressure ordinarily required, thus permitting the elimination of all high pressure equipment and gaining a new and more desirable mode of operation.

In present fluid driven motor-pumps, so far as I have been able to ascertain, there has not heretofore been provided a valving means which does not stop the flow of power fluid to one end of the motor piston chamber before admitting it to the opposite end of the chamber, thus stopping completely, though momentarily, all flow of power fluid into the motor. In an analogous manner all flow of exhaust motor fluid from the chamber is stopped completely at the instant of valve shift at the end of each stroke.

The result of the complete stoppage of the flow into the motor, when a liquid is used as the power fluid, is the stoppage of the entire column of virtually incompressible liquid, and the conversion of the momentum of the column into a rapidly built up excessive pressure which centers at the point of valving, producing an extreme shock, or what is commonly known as "water hammer". Heretofore, insofar as I have been able to ascertain, there has been no method developed of either preventing "water hammer" in liquid driven motor-pumps, or of absorbing the shock, therefore prohibiting the operation of liquid driven motor-pumps at any but low velocities in order to prevent bursting.

In my invention this problem is solved in valving by the use of a novel relation of ports, closures, and timing which allows uninterrupted flow of power fluid into and exhaust fluid out of the motor, thereby eliminating the cause of "water hammer". My novel relation of ports, closures and timing is identical whether that relationship exists in one compound or in several separate valve structures of any type. In my preferred embodiment the valve closure of the one valve begins to register and diminish the flow of power fluid into the one end of the motor piston chamber, and simultaneously the port of the other intake valve begins to register and permit the flow of the power fluid to the opposite end of the motor piston chamber in direct proportion. The valve shift begins, proceeds, and is completed without changing either the combined intake port area or the combined exhaust port area. Obviously an action less desirable, due to excessive loss of power fluid and excessive time required for the shift, could be obtained by opening the second port completely before the first port begins to close, instead of having the opening and closing occur simultaneously. Such action would be based upon the principle used in my preferred embodiment, of not closing the one intake port before opening the second.

In the preferred embodiment of my invention, the entire pumping mechanism is located above and intakes from above the motor, thereby eliminating the conduit otherwise within the assembly for conducting the production fluid past the motor. Various benefits are derived from such an arrangement, some of which are: greater motor piston area; increase of pump intake area; reduction of interference with pump valves by foreign substances; and, elimination of the possibility of the pump intake being choked by foreign substance on the well bottom.

My device is so designed that the pump load upon both the upward and the downward strokes may be identical, also that the working area of the motor piston may be identical upon both the upward and downward strokes. This produces a uniformly smooth piston travel and therefore permits a much higher piston speed than is usually possible.

With these and other objects in view as will more fully appear hereinbelow, my invention consists in the construction, novel features, and combination of parts hereinafter more fully described, pointed out in the claims hereto appended, and illustrated in the accompanying drawings, in which,

Figure 1 is a vertical section of the upper portion of my motor-pump, and shows particularly the construction of a preferred type head, as well as that portion of the device which is positioned immediately therebelow;

Figure 2 is a transverse section taken along the line 2—2 of Figure 1;

Figure 3 is a transverse section taken along the line 3—3 of Figure 1;

Figure 4 is a fragmental vertical sectional view of the portion of the device lying below Fig. 3;

Figure 5 is a sectional view taken along the line 5—5 of Fig. 4;

Fig. 6 is a view similar to Fig. 4 but is taken at a radial position ninety degrees to the right hand of that at which Fig. 4 was taken;

Figure 7 is a transverse sectional view taken along the line 7—7 of Fig. 6;

Figure 8 is a fragmentary detail of a portion of the device;

Figure 9 is a fragmentary vertical sectional

view of the portion of the device lying below Figs. 4 and 6;

Figures 10 and 11 are respectively transverse sections taken along the lines 10—10 and 11—11 of Fig. 9;

Figure 12 is a fragmentary vertical section of the portion of the device that lies directly below the portion shown in Fig. 9;

Figures 13, 14, and 15 are transverse sections taken respectively along the lines 13—13, 14—14 and 15—15 of Fig. 12;

Figure 16 is a fragmentary vertical sectional view of the portion of the device lying directly below the portion shown in Fig. 12;

Figure 17 is a fragmentary view of the portion of the device lying directly below the portion shown in Fig. 16 and is partially in section;

Fig. 18 is a schematic view of my complete pumping device including a head (Fig. 1) and the pump and motor structure embodying two motor units. The pistons are at the bottom of their stroke;

Fig. 19 is a view identical to Fig. 18 except that the pistons are at the upper end of their stroke, and the valve parts in corresponding position.

Like characters of reference designate like parts in all the figures.

It is understood that various changes in the form, proportion, size, shape, weight and other details of construction, within the scope of my invention may be resorted to without departing from the spirit or broad principle of my invention and without sacrificing any of the advantages thereof; and it is also understood that the drawings are to be interpreted as being illustrative and not restrictive.

The inventive idea involved is capable of receiving a variety of mechanical expressions one of which, for the purpose of illustrating the invention, is shown in the accompanying drawings.

I now refer more particularly to Figs. 1, 2, and 3 of the drawings in which is illustrated a head particularly adaptable for use in an extremely sandy condition of the production fluid, the power fluid, and/or if the well is without liner.

The reference numeral 3 indicates the lower end of a tubing string for delivering power fluid from the earth's surface. To this tubing string is attached the upper end of a hollow substantially cylindrical upper member 40 having a hemispherically concave ground joint seat 41 in its lower end, and a central lower reduced orifice 42. A lower hollow member 43 having a longitudinal bore 44 and an upper hemispherically convex ground joint seat to fit within the seat 41 is provided beneath the member 40 and is held in position by a coupling 45 and the upper end of a pipe 73. If preferred the member 43 may be made integral with the coupling 45, but if not the two should be arranged in assembled relation before the following described passages are formed therein.

It will be noted that the convex upper end of the member 43 will properly seat within the seat 41 even though the tubing string 3 is disposed at an angle with relation to the member 43. The coupling 45 is equipped with a plurality of radially spaced passages 47, and also with another set of drain passages 48. The passages 47 are radially alternated with the passages 48, and lead upwardly from the interior of the pipe 73 to the annular space surrounding the upper member 40. This annular space is formed by the interior surface of a second and circumferentially larger tubing string 49 surrounding the string 3 and joined to the coupling 45. The tubing 49 extends to the earth's surface. The passages 48 extend downwardly from the convex seating surface of the member 43 and outwardly through the side walls of the member and through the wall of the coupling 45.

Positioned within the bore 44 of the member 43 is an upwardly closing check valve structure consisting of a guide spider 50, a valve 51 slidable therein, and a compression spring 52.

In using this head the power fluid is delivered downwardly through the tubing 3, member 40, reduced bore 42, bore 44 and to the tubing 75. The check valve is opened by the pressure of the fluid and the tubing 75 carries the fluid to a place of work which is later to be described hereinbelow. The production fluid passes upwardly in the annular space around the tubing 75, through the passages 47 and into the tubing string 49.

Proceeding with the description of the motor-pump proper, the tubing 75 is provided with a longitudinally extending partition 78, which begins at a point near the upper end of the tubing 75, as shown in Fig. 1, and extends to the opposite end of the tubing, as illustrated diagrammatically in Fig. 18. The partition 78 at its upper end converges with and is connected to one outer wall of the tubing 75, and below this point forms two separate longitudinally extending passages 79 and 80. The passage 79 communicates with the tubing 3 to convey power fluid downwardly, while the passage 80 is for conveying used power fluid upwardly. A lateral port 81 forms a communication between the passage 80 and the passages 47.

A cylindrical plunger sleeve 82 loosely surrounds the tubing 75 forming an annular passage for discharge of produced fluid, and at its lower end the sleeve 82 is threaded into the upper end of a slidable pump piston head 83. A second cylindrical sleeve or liner 84 is pressed into the barrel 73 and positioned around the sleeve 82, as shown in Fig. 1. The two sleeves 82 and 84 are ground to a liquid tight fit with each other.

An enlarged section 85 of the pump barrel is threadedly connected to the lower end of the section 73, and has a plurality of "breathing" ports 86. The sleeve 84 terminates just above the ports 86. A sleeve 87 is pressed rigidly in position around the pump piston head member 83, and becomes a part thereof. Around the tube 75 and within the sleeve 82 and piston head 83, is left an annular space 88 which communicates at its upper end within the section 73 and with the passages 47.

Attached to the lower end of the piston head 83 by threads 89 (Fig. 4), is a lower head section 90 having a plurality of upwardly extending radially spaced ports 91, each of which is provided with a ball check 92. The ports 91 at their lower ends diverge outwardly through the wall of the lower head section 90. An annular space 93 is provided between the outer surface of the head section 90 and the inner surface of the barrel section 85. The ports 91 form a means of communication between the annular spaces 88 and 93 when the balls 92 are unseated.

As best may be seen in Figs. 4, 5, 6 and 7, the tube 75 is provided in its walls with a pair of oppositely disposed longitudinally extending grooves 94 and 95, and as shown in Figs. 6, 7 and 8, the head section 90 is equipped with two runners 96 which are anchored with the head section

90 and which slide within the grooves 94 and 95. The runners 96 are held within the head section 90 by the upper end of a hollow piston rod 97 which is threaded into the head section 90, and which impinges a laterally extending lug 98 (Figs. 6 and 8) upon each of the runners. The grooves 94 and 95 and the runners 96 co-act with a member 163 (Fig. 16) to prevent any rotative action of the motor piston head therebelow with relation to the tube 75.

The lower end of the barrel section 85 is connected by a coupling 99 (Fig. 9) to the upper end of a tubular packing-gland housing and intake port sleeve 100. The coupling 99 also acts as a check valve and packing housing.

The lower portion of the coupling 99 is internally threaded and receives in turn, starting at the upper ends of its threads, two metal rings 101 and 102, the annular flange 103 of a cup-leather 104, a cushion ring 105 of leather, a jamb-nut 106 for holding the flange and cushion ring firmly against the ring 102, an annular cage 107 for retaining check valve balls 108, and a lower annular ball cage 109 for retaining the balls. The elements 101, 102, 103, 105, 106, 107, and 109 are all provided with radially spaced through perforations adapted to be aligned to form a plurality of the rough passages, and the lower cage member 109 has seats for the balls at the upper orifice of each of its perforations. The wall of the upper cage member 107 is spaced sufficiently from these seats to permit the balls to become unseated for allowing upward flow of a fluid. The members 101, 102, 103, 104, 105, 106, 107, and 109 are all formed in segmental sections in order to permit their assembly about piston rod 97. The ends of the various segments are illustrated by radial lines in Fig. 11.

At a point beneath the lower cage member 109, the sleeve 100 is provided with a plurality of radially spaced intake slots or ports 110 for receiving production fluid from the well.

Below the ports 110 the sleeve 100 is internally threaded as shown at 111 and 112. The larger threads 112 are for coupling the sleeve to a tubular power unit housing 113, (Fig. 12), and the smaller threads 111 receive the following packing elements in turn starting at their upper end: A metal seating ring 114; a resilient packing ring 115; a jamb-nut 120; a leather cushioning ring 121; the flange 116 of a cup-leather 117; an annular jamb-nut 118; and, an annular lock-nut 119. The members 114, 115, 116, 117, 118, 119, 120 and 121 are all formed in segmental sections in order to permit their assembly around the rod 97.

The operation of the pump above described may be explained as follows:

It should first be taken for granted that a power is to be furnished (motor will be later described) for imparting a reciprocal motion to the tubular piston rod 97.

The first upward movement of the rod 97 will move the pump piston head members 90 and 83 (Figs. 4 and 1) and the sleeve 82 upward, which movement will seat all of the balls 92. This will remove downward pressure upon the balls 108 (Fig. 9) thereby permitting them to be lifted by the static head pressure of the outside fluid, and permitting the flow of the outside fluid through the ports 110 and into the annular space 93 being vacated by the piston members 90 and 87. Downward movement of the rod 97 and the piston head member 90 and 83 will seat the balls 108 and unseat the balls 92 to permit the production fluid in the annular space 93 to be forced upwardly into the chamber 88 above the plunger sleeve 82, in which chamber one-half of the equivalent of the maximum volume in the chamber 93 takes the place of the plunger sleeve 82 which is withdrawn by the same movement, and from which chamber is discharged the remaining one-half volume through the openings 47. The next upward stroke will not only fill the annular space 93 lying below the piston, but will seat the balls 92 and force the fluid above plunger sleeve 82 upward through the annular space 88, through the openings 47, and into the annular space between the tubes 3 and 49, from whence on the following strokes of the piston it will be forced from the upper end of this space at the earth's surface. Thus it will be noted that the pump discharges from chamber 88 an equal volume on each stroke, providing balanced action and balanced load.

The ports 86 (Fig. 1) are provided in order to permit adjacent interior annular space to be filled with the well fluid upon the downstroke and to be emptied upon the upstroke. This gives what might well be termed a breather effect.

It will be noted that neither the balls 92 nor 108 are divided by any cage, which is conventional with ball check valves in general, but instead depend upon the annular space within which they are contained, and upon each other for proper alinement over their respective passages. (See Fig. 5.)

Each of the balls 92 is seated in the upper end of one of the ports 91 and when in a seated position approximately one-half of its diameter lies within the port. The lower end of the member 83 lies sufficiently close to the upper surfaces of the balls to prevent the escape of each ball from a vertical position over its respective port 91. The ports 91 are sufficiently close together to insure proper seating of one of the balls over each port, even though the lower end of the member 83 was positioned a greater distance from the balls, provided of course that the distance is not greater than twice the diameter of the balls. The balls 108 (Fig. 9) are similarly mounted over the ports in the member 109, except that the aligned passages in the elements 102, 103, 105, 106 and 107 are staggered with relation to the passages in the element 109.

The packing ring 115 and the cup-leather 117 in the element 100 prevent upward movement of fluid along the exterior of the piston rod 97.

A description of a power unit for reciprocating the tubular piston rod 97 will next be made by reference to Figs. 12 to 19 inclusive.

The piston chamber housing 113 which has a smooth interior surface is threadedly engaged at its upper end into the threads 112 of element 100. The tubular piston rod 97, at a point in the upper portion of the housing 113, is enlarged exteriorly but not interiorly, and while shown to be of one piece construction, it is obvious a similar result may be obtained by use of a threaded cuff, and this enlarged portion 130 is provided with exterior threads 131. The bore of the element 97 is slightly enlarged at its extreme lower end as indicated by the reference numeral 132. The threads 131 engage the upper end of a substantially tubular outer piston shell 133, which centrally is provided with an annular inward projection 134. Above and below the projection 134, respectively, the shell is equipped with annular grooves or notches 135 and 136. In communication with notch 135 are a plurality of radially

spaced vertical passages 137, which extend upwardly in the wall of the shell 133 to its extreme upper end. Extending downwardly within the wall of the shell 133 from the groove 136 to its lower end is a plurality of radially spaced passages 138 similar to the passages 137 thereabove. Slidably disposed around the tube 75, with its upper end seated in the enlarged portion 132 in the bore of the element 130, is a tubular port carrying sleeve 139. The sleeve 139 has oppositely disposed longitudinal indented portions 140 (Figs. 13, 14 and 15) in each of its sides, which indented portions slide in the grooves 94 and 95 in the tube 75 to prevent its independent rotation with relation to the sleeve 139. Around the sleeve 139 but less in length is a sildable sleeve valve 141. The sleeve 139 is held rigidly in place and the downward movement of the sliding valve 141 is limited by the upper end of an externally threaded substantially tubular head 142, which is threaded into the lower end of the shell 133, and which head forms the lower end of the power piston which drives the tubular piston rod 97 to reciprocation. The lower end of the power piston is indicated by the numeral 145. The annular space between shell 133 and the sleeve 139 within which the sliding valve 141 is permitted a limited reciprocal movement is indicated by the reference numerals 144 (Fig. 12). The sliding valve 141 is provided on its inner surface with two longitudinal extruded splines, or tongues, 143 which have a sliding engagement within the indentations 140 of the port carrying sleeve 139.

The tube 75 has two oppositely disposed longitudinal through slots 146 and 147 which respectively communicate with the passages 79 and 80 at opposite sides of the partition 78. The respective upper ends of the slots 146 and 147 are indicated by reference numerals 148 and 149 (Fig. 12) and their respective lower ends are indicated by numerals 150 and 151 (Fig. 16). The length of the slots 146 and 147 are approximately equal to the length of stroke of the power piston, plus the distance between the bottom of the port 154 and the top of the port 152, plus the overthrow distance at each end.

The port carrying sleeve 139 has two upper lateral through ports 152 and 153 (Fig. 12) which are oppositely disposed and which are radially coincidental respectively, with the slots 146 and 147 in the tube 75, and is also provided with two lower through ports 154 and 155 which are radially spaced similarly and in respective vertical alignment with the ports 152 and 153. The two upper ports 152 and 153 are vertically coincidental with the groove 135 in the shell 133 while the lower ports 154 and 155 are vertically coincidental with the groove 136 in the shell 133.

In order to illustrate the relative lengths of the annular space 144, with the valve sleeve 141, and the lengths and spacing of the ports 152 and 154, and 153 and 155, with relation to the length of the space 144 and the length of the sleeve 141, it may be assumed that the ports 152, 153, 154, and 155 are each equal vertically to one aliquot part as related to the valve sleeve 141, which is of nine parts. The vertical distances respectively between the ports 152 and 154, and between the ports 153 and 155 equals two aliquot parts, and the vertical length of the annular space 144 equals twelve and one-half parts. However, as will be more fully described hereinbelow, only twelve parts of the space 144 are utilized to accommodate the valve sleeve 141 in its travel, one-fourth part at each end of the space being used as a fluid stop chamber.

The sliding valve 141 is provided with a through port 156 the vertical center of which lies an equal distance from each end of the sleeve 141, and which is radially coincidental with the ports 152 and 154 in the sleeve 139. Said port 156 is three aliquot parts long with relation to the sleeve 141, and its center is coincidental vertically with the center of the port 154 when the valve is at the lower end of its throw, and with the center of the port 152 when the valve is at the upper end of its throw. The valve 141 also has two vertically spaced ports 157 and 158 each two parts in length, spaced apart vertically three parts, and which are radially coincidental with the ports 153 and 155 in the port carrying sleeve 139. The uppermost of these ports, 157, has its upper edge vertically alined with the upper edge of the port 153 when the sliding valve is at the lowermost end of its throw, while the lower port, 158, has its lower edge alined vertically with the lower edge of the port 155 in the sleeve 139 when the valve is at the upper end of its throw.

From the foregoing description it may be seen that if a power were to be generated to reciprocate the sliding valve 141 in proper timed intervals, and that if a fluid under sufficient pressure was being delivered downwardly in the power side of the tube 75, or in other words through the passage 79 therein, operation of the power piston would take place in substantially the following manner, to-wit:

With the valve 141 at the lower end of its throw in the position in which it is shown in Fig. 12, opening is established between the power side 79 of the tube 75 through the longitudinal slot 146 in the side of the tube 75, through the port 154 in the port carrying sleeve 139, through the port 156 in the sliding valve 141, through the annular space or groove 136, and through the vertical passages 139 in the shell 133, into an annular space or piston chamber 159 below the power piston head. Considering the space 159 to be closed at its lower end, the piston head would therefore be moved in an upward direction, providing exhaust of any fluid in the piston chamber above the piston and below the packing gland in the lower end of the sleeve 100 is simultaneously permitted.

During this upward movement, a discharge is being permitted from the piston chamber above the piston head downward through the passages 137 in the shell 133, through the groove 135, through the port 157 in the sliding valve 141, through the port 153 in the port carrying sleeve 139, through the longitudinal slot 147 in the tube 75, and into the exhaust space or passage 80 in the tube 75 where it is free to move upwardly to discharge through the head (Fig. 1) above the previously described pumping unit, and into the production tubing 49.

If, when the power piston reaches the approximate upper end of its stroke, the sliding valve 141 should be suddenly powered to move to the upper end of its throw, the power fluid would be permitted to flow from the passage 79 through the longitudinal slot 146 in the tube 75; through the port 152 in the port carrying sleeve 139, through the port 156 in the sliding valve 141, through the annular space 135, and through the vertical passages 137 into the chamber above the power piston. This would alter the direction of movement of the piston and start it in a down-

ward direction providing fluid in the chamber 159 were permitted to exhaust.

Upward movement of the valve would simultaneously permit exhaust of the fluid from the chamber 159 below the power piston through the vertical passages 138 in the shell 133, through the annular groove 136, through the port 158 in the sliding valve 141, through port 155 in the port carrying sleeve 139, and through the longitudinal slot 147 in the tube 75 into the exhaust passage 80. This cycle would of course be repeated as long as the power fluid was being delivered.

The lower end of the head 142 (Fig. 12) is made integral with the upper end of a section 160 of piston rod which is identical in cross section to the piston rod 97 above the power piston. The section 160 terminates below the chamber 159 in a threaded head 161 (Fig. 16). A ring 163 carrying two upwardly extending splines which are adapted to travel in the grooves 94 and 95 in the tube 75, is provided around the lower end of the head 161, and is held in place by a cap 162 threaded on to the head 161. The element 163 serves, together with the members 96 (Figs. 7 and 8) to lock the entire piston assembly against independent rotation upon the tube 75.

The lower end of the barrel 113 (Fig. 16) is connected by an interiorly threaded coupling 165 to a pipe section 166 which acts as a housing for the lower end of the tube 75, which tube extends slightly below the lower end of the piston rod 160, when that rod is at the lower end of its stroke. The grooves 94 and 95 extend entirely to the lower end of the tube 75, which is seated at its lower end in a socket in the upper surface of a thrust nut 167 (Fig. 17) carried by a coupling 168, which in turn is threadedly attached to the lower end of the pipe 166. The coupling 168 also carries a lock-nut 169 for preventing inadvertent loosening of the thrust nut 167. The lower end of the coupling 169 is preferably closed by a pipe 170 which has a closed lower end.

The previously described coupling 165 (Fig. 16) is interiorly threaded in its central portion and acts as the housing for a packing gland which preferably comprises the following superimposed elements beginning at the bottom of the threads: a seating ring 171; a resilient packing ring 172; a jamb-nut 173; the flange 176 of a cup-leather 175; a leather cushioning ring 174; a jamb-nut 177; and, a lock-nut 178. The packing elements last above described act to close the bottom of the piston chamber 159, and each is formed in segmental sections to permit assembly around the section 160.

Near the bottom of the member 75 is a series of ports 179 (Figs. 17 and 18) opening into the exhaust passage 80 for the purpose of equalizing static head pressures, and for permitting displacement of fluid caused by the reciprocation of the lower end of the piston rod 160, creating a "breathing" effect which acts as a load and is compensated for by an equal but opposite effect due to a slight alteration of pump piston to pump plunger ratio.

As a means for operating the sliding valve 141 at each end of each stroke of the power piston the following described structure is employed.

Adjacent the upper end of the port carrying sleeve 139 (Fig. 12), a slight distance below the upper end of the annular space 144 within which the slide valve 141 reciprocates, and radially at approximately sixty-five degrees from the position of the slot 147 in the tube 75, the port carrying sleeve 139 is provided with a through perforation or port 180 the top edge of which is slightly below the upper end of the annular space 144 and which communicates therewith. In the same radial position, and in such a vertical position as to cause its lower end to register with the port 180 when the power piston is approximately at the upper end of its throw, a longitudinally extending through slot or port 181 is provided in the wall of the tube 75. The port 181 opens into the exhaust passage 80 of the tube 75. At a radial position lying approximately fifty degrees to the left hand of the port 180, the port carrying sleeve 139 is provided with a port 182 the top edge of which is coincidental with the upper end of the annular space 144 and communicates therewith. This port 182 is in such radial position as to afford communication between the space 144 and the power delivery passage 79 of the tube. Adjacent its lower end, and lying approximately one hundred and eighty degrees from the port 180, the port carrying sleeve 139 is provided with a similar port 183 having its lower edge coincidental with the lower end of the annular space 144 and communicating therewith. At a radial position lying approximately one hundred and eighty degrees from the slot or port 181, and in such a vertical position as to cause its lower end to register with the port 183 when the power piston is approximately at the upper end of its stroke, the tube 75 is provided with a longitudinal slot or port 185. The port 185 opens into the power delivery passage 79 of the tube 75.

As may best be seen in Fig. 16, the tube 75 is provided with two other longitudinal ports or slots, the upper one of which is designated by the reference numeral 186 and the lower one by the numeral 187.

The port 186 is in the same radial position as is the port 182 in the port carrying sleeve 139, and is in such a vertical position as to cause the port 182 to register with its upper end when the power piston is at approximately the lower end of its stroke.

The port 187 is in the same radial position as is the port 184 (Fig. 12) in the port carrying sleeve 139, and is in such a vertical position as to cause the port 184 to register with its upper end when the power piston is at approximately the lower end of its stroke.

As is clearly shown, the port 186 passes through the wall of the tube 75 lying within the power delivery passage 79, while the port 187 passes through the wall of the exhaust passage 80.

In the position shown in Fig. 12, the power piston has just reached the upper end of its stroke, and the port 183 has registered with the lower end of the port 185 so that power fluid may pass into the annular space 144 beneath the sliding valve 141 to cause it to shift upwardly in its annular space. At the same time, the port 180 has just registered with the lower end of the port 181, and power fluid which is in the annular space 144 above the valve 141 is free to exhaust into the passage 80 in order to permit the valve 141 to shift.

If the power piston is traveling slowly when this position is reached, the sliding valve will be moved instantly upward and the power piston will simultaneously, or approximately so, change its direction. However, if the power piston is traveling at a high rate of speed, it may travel

upward a slight distance further, or until the ports 183 and 180 have reached, or closely approached, the upper ends respectively of the slots or ports 185 and 181 in the tube 75. In other words, the traveling speed of the power piston will determine the exact point at which the sliding valve will complete its shift. At the upper end of the stroke of the power piston, the ports 182 and 184 in the ported tube 139, and the ports 186 and 187 in the tube 75, perform no function.

During the downward movement of the power piston the sliding valve 141 will remain in the upper end of the annular space 144 until the ports 182 and 184 in the ported tube or sleeve 139 simultaneously reach the upper ends respectively of the slots or ports 186 and 187 in the tube 75.

At this point the sliding valve will be moved downwardly by power fluid entering the annular space above the valve through the ports 186 and 182, and the fluid then in the annular space 144 below the valve will be exhausted into the passage 80 through the ports 184 and 187, as the valve changes its position.

It will be noted that the ports 180 and 184, which form communication with the exhaust passage 80 in the tube 75, are slightly nearer together vertically than are the ports 182 and 183 which lead from the power delivery passage 79. This is for the purpose of trapping a slight amount of the exhaust fluid in the annular space 144 to act as a cushion or stop for the sliding valve 141 at each end of its stroke. This stop is obtained because the exhaust ports 180 and 184 are located respectively a short distance below and above the upper and lower ends of the space 144 within which the valve 141 shifts. Therefore a small amount of the fluid in the space is prevented from exhausting upon each stroke of the valve, thereby forming a fluid stop for the valve at each end of its stroke for preventing injury to the valve, and also providing a passage for the entrance of actuating fluid at opposite ends of the valve. It will be noted that the valve 141 always shifts in the direction in which the power piston is traveling. Also, that during the stroke of the piston, the valve 141 is held stationary with relation to the piston by power liquid trapped in the annular space 144 with no mode of escape.

Because of the fact that much less fluid pressure is required to reciprocate the sleeve valve 141 than is required to reciprocate the power piston, the fluid pressure in the fluid delivery passage 79 would be more than adequate to shift the sleeve valve, and thus the valve 141 is assured positive action at all times.

A valve having such an arrangement of ports and closures as that shown in Figs. 12, 13, 14, 15 and 16 will function substantially as follows:

When fluid under pressure is admitted from the passage 79 through the ports 185 and 183 into the annular space 144 below the valve sleeve 141, the valve sleeve will be forced upwardly, providing exhaust of the fluid is permitted from the space 144 above the valve sleeve. This exhaust is accomplished by the co-incidence of the ports 180 and 181 which permit the fluid to exhaust into the passage 80 and thence into the production tubing 49 thereabove. When the valve sleeve 141 has moved upwardly one aliquot part, closure of ports 153 and 154 begins, and the opening of ports 152 and 155 begins, and each of these actions progresses co-incidentally and proportionately until completed by motion of the sleeve a distance equal to three aliquot parts. Hence, a continuous undiminished flow of piston motive fluid from the intake to the exhaust is maintained while diversion of power and exhaust fluid to and from the respective opposite ends of the piston chamber occurs. Upon completion of the above described motion of the valve sleeve 141, the direction of the motion of the piston is reversed to move downwardly. Upon the piston nearing the lower end of its down stroke, the port 182 (Fig. 12) and the port 186 (Fig. 16) become co-incident and co-act to supply motive fluid from the passage 79 to the annular space 144 above the valve sleeve 141 to shift it downwardly; and, ports 184 and 187 which are co-incident, co-act to permit exhaust of fluid from the annular space 144 below the valve sleeve 141 into the passage 80, from whence it passes upwardly to the production tubing. The last described motion of the valve sleeve progresses through three aliquot parts, and accomplishes reversal of motion of the piston and completes its cycle.

It will be noted that motion of the valve sleeve 141 equals three aliquot parts and is in the direction of the piston travel. The direction of travel might be reversed by reversal of the arrangement of ports, but the valve action is intended to occur in the shortest possible period of time, thereby permitting a high piston speed, and this purpose is best accomplished by moving the valve sleeve in the direction of the piston motion.

The most common or universal method of valving, insofar as I am informed, is that in which the motive intake valve to a given piston chamber is closed before the exhaust valve to said chamber is opened, thus preventing what is commonly known as "slip." This involves complete arrest or stoppage of motion in the serving column of motive fluid, in this case a virtually incompressible liquid, and if the column is of any considerable height, or if it is moving at any considerable velocity, its force is opposed by the valve or valves. Valving in that manner is, to say the least, impractical and has the effect of producing a blow delivered at the valving point and extending throughout the apparatus, which is commonly known as "water hammer."

In my device, with the valve sleeve 141 at the position shown in Fig. 12, ports 154 and 156 serve to supply piston motive fluid from the passage 79 to the lower end of the piston chamber, and the ports 153 and 157 serve to exhaust used motive fluid into the passage 80 from the opposite end of the piston chamber. The ports 183 and 185 serve to supply valve motive fluid from the passage 79 to the annular space 144 below the valve sleeve 141, and the ports 180 and 181 serve to exhaust used fluid from the annular space 144 above the valve sleeve 141 into the passage 80 from whence it may pass into the production tubing. The piston is shown in Fig. 12 at the point in its upward stroke when the ports serving the valve sleeve motive fluid below the valve, and the ports serving to exhaust fluid from above the valve sleeve, are co-incident. When the valve sleeve 14 moves upwardly one aliquot part, closure of ports 153 and 154 begins, and opening of ports 152 and 155 simultaneously begins. The ports named as closing; continue to close in exact proportion that those ports named as opening, open. At the medial point of total motion, each of the four ports named are at one-half normal area, therefore one-half flow of piston motive fluid passes from the motive fluid passage 79 through ports 146, 152, and 156 into the annular space 135, and through ports 157, 153 and 147

into the exhaust passage 80, from whence it may pass to the production line. Similarly, one-half of the normal flow passes from the passage 79 through ports 146, 154 and 156 into the annular space 136, and through ports 158, 155 and 147 into the exhaust passage 80, thence to the production tubing 49 (Fig. 1). It will be clear, therefore, that during the first one-half of the travel of the valve sleeve 141, the quantity of the piston motive fluid to drive the piston in a given direction has been progressively diminished while simultaneously begun and proportionately increased into the opposite end of the chamber, and the exhaust ports serving each end of the piston chamber have moved simultaneously to positions where an exact balance of intake piston motive fluid port area and exhaust port area are equal at each end of the piston chamber and the piston comes to rest at the end of its stroke. Further upward travel of the valve sleeve 141 increases the proportion of piston motive fluid diverted to the upper end of the piston chamber and the piston moves in the opposite direction, or downwardly. This is repeated inversely at the lower end of the piston travel, substituting port 186 for port 185, port 182 for port 183, port 187 for port 181, and port 184 for port 180, and the piston cycle is completed.

Clear understanding of the foregoing description will disclose that at the medial point of motion of the valve sleeve 141, the downward motion of the motive fluid in the passage 79, and the upward motion of the exhaust fluid in the passage 80, are each separately continued to the earth's surface. The motive fluid may move downwardly in the passage 79, pass through the ports in the piston and return upwardly through the passage 80 and the production tubing to the earth's surface without change of impedance other than the frictional load, by reason of the fact that there is no arrest or impedance in the motion of the flow of the motive fluid during the period of valve shift, or during reversal in the piston travel, and therefore there can not be what is commonly known as "water hammer."

Attention is called to what may seem to be obvious, viz., that the port 156 in the sleeve 141 actually serves as two ports by serving each end of the piston barrel with piston motive fluid. It seems obvious then that a sleeve increased in length over that shown, may be used, also that arrangement and location of the other ports may be varied, or that a series of separate valve slides for closure of the ports or even an entirely separate set of valves might be used equivalently for accomplishment of the purpose, which is, an uninterrupted flow of a liquid power fluid.

It seems desirable to direct attention to provisions which have been made for the prevention of stalling on "dead center." The valve sleeve 141 being independently supplied with motive fluid, depends for its movement only upon the co-incidence of the ports serving it, and when the piston reaches a given point in its upward travel, incidence between the motive fluid port 183 carried by the piston, and the motive fluid port 185 occurs, and connection of the motive fluid passage 79 is established, and incidence of the exhaust port 180 carried by the piston, and the exhaust port 181, causes connection with the exhaust passage 80, (ports 181 and 185 are in the form of slots carried in the stationary member 75). Thus motive fluid from the passage 79 enters the annular space 144 below the sleeve 141, through the ports 183 and 185, and due to the form of the port continues to furnish motive fluid to move the sleeve during further motion of the piston. Upon the total permissible motion of the sleeve, reversal of the motive fluid from below to above the piston is accomplished and the piston motion is reversed from upward to downward. When the piston nears the end of its downward stroke motive fluid port 182 carried by the piston becomes incident to the motive fluid port 186 (Fig. 16) and exhaust port 184 carried by the piston becomes incident with the exhaust port 187, causing connection with the passage 80 carried by the stationary element 75. Motive fluid from the passage 79 then enters the annular space 144 above the sleeve 141 through ports 182 and 186 and the sleeve is forced downwardly through its permissible motion at which time the piston motive fluid is diverted from its flow into the upper end of the piston chamber to flow into the lower end of the piston chamber, completing a cycle. It is therefore obvious that valve action is entirely independent of momentum or piston motion, once incidence of motive fluid valve ports occurs, and that if motive fluid is under pressure valve shift will occur. The foregoing paragraph applies equally whether a liquid or a gas valve is used.

It may appear from the foregoing that an alternative system of valving is suggested, this is not intended. The purpose of the use of the two described methods is an attempt to suit one device to use in all phases of pumping usually encountered in any one oil well. In nearly all wells a change of equipment for recovery of oil becomes necessary during the productive life of a well. When pumping first becomes necessary the well will usually supply enough natural gas for use as motive fluid and usually a "gas lift" is used. Later, when gas pressure is substantially exhausted it is usual to remove the gas lift and use a sucker rod reciprocating pump. Therefore, if the present device is suited for use during the entire pumping life of the well it would render unnecessary the present requirement and loss of time and production incident to changing equipment. Furthermore, the use of the liquid valve alone and during the period when gas might be used would involve waste of gas during the gas producing period.

It may be thought that a gas valve alone would be adequate, substituting air for gas when sufficient gas became unavailable but all oil wells produce some gas as long as oil is produced and if air should be used the mixture of the air and the higher oil fractions and gas would form explosive mixtures which would thereby render that mode of production unavailable.

It is evident therefore that in practice it will be desirable to supply with the device two valve sleeves one in which the ports are spaced suited to the use of gas and the other having ports spaced making it suited to the use of liquid. As set out hereinabove all other parts of the device in either case remain identical.

For emphasis in my foregoing specific description, I have avoided my principle for amplification of motor piston area as applied to my preferred embodiment. For simplicity and clarity of description the motor has hereinbefore been described as having but one motor piston and one motor piston barrel 113; and said barrel has been described as being connected by a coupling 165 to a housing 166 for the lower end of the tube 75 and piston rod 160.

My preferred embodiment actually has two mo-

tor pistons, as shown in Figs. 18 and 19 and two motor piston barrels, the second of which is situated directly below the first, and connected to the first by a gland containing coupling identical with the coupling 165; and the heretofore described coupling 165 connects the housing 166 to the lower end of the second motor piston barrel. The tube 75 is built the necessary extra length to serve the second motor piston as it serves the first; tube 75 then terminates within the thrust nut 167 as shown in Figs. 16 and 17; the piston rod 160 is also built the necessary extra length and connects the second piston to the first; the piston rod 160 extends from the lower end of the second piston through the coupling 165 and terminates within the housing 166 as shown in Figs. 16 and 17, as previously described; the coupling connecting the two motor barrels contains gland members identical to those closing respective ends of barrel 113; and all description relating directly to the motor barrel 113 and its contents, applies also to the second motor barrel and its contents, and as well to any additional barrels and their contents.

The force the motor is capable of exerting is directly proportional to the degree of amplification of motor piston area, and the degree of amplification desirable depends both upon the size of the pump to be actuated, and the depth from which liquid is to be pumped. The specific device described doubles the motor piston area through use of my amplification principle. As much additional motor piston area amplification will be employed as each individual well condition requires or justifies, by building a unit having the required number of motor pistons and piston chambers suited to a specific height of lift and to the motive fluid line pressure desired, it not being possible to change characteristics of a unit by addition or subtraction of pistons and barrels, due to the fixed length of the element 75.

In further consideration of the power piston valve structure it is pointed out that the piston in itself acts as a sliding valve over the tube 75, and that its movement governs or times the shifting of the sleeve valve 141. Also that the port carrying sleeve 139 could be formed as a continuation or integral part of the hollow piston rod 160, in which event the piston rod would actually be a part of the valve structure, or, in other words would act as a timing valve over the tube 75. Or, the piston in itself could be arranged to carry the ports now carried by the port carrying sleeve 139. Also, that the hollow piston rod could be used over either a single power delivery or single exhaust tube, and other mechanical arrangements made to take care of either the exhaust or delivery of the fluid not being carried by the tube.

As far as I know there has never before been produced a valving means for any application whatsoever, either above or below the earth's surface, for the purpose of disconnecting a passage to one receptacle and connecting it with a second receptacle which does not close the passage to the first receptacle before opening said passage to the second receptacle. It is obvious that the details of the valve structure might be changed and yet use this novel principle particularly adapted to the prevention of water hammer in liquid driven motor-pumps; also that the valving mechanism above described with relation to the power unit may be used to control movement of a single power piston, or may be used as a unitary valving means for a series of power pistons and chambers; also, that details of the valve structure might be changed and yet use the novel principle involved in the opening and closing of the power intake ports and of the power exhaust ports in such a manner as to avoid stoppage of flow of the power fluid and consequent water hammer.

Obviously, the pumping unit could be positioned below the power unit if desired, by connecting a pump rod with the lower end of the power piston rod and by connecting the pump discharge to the lower end of the motor exhaust line 80. Such a device would operate, but many of the advantages present in the preferred embodiment would be lost.

Attention is called to a very important feature of the device embodied in the power delivery and exhaust tube 75. This feature includes the arcuate partition for lending strength against difference of pressure between the two equal area passages 79 and 80 (see Figs. 5 and 7), thereby permitting the largest possible useful area for a given size in cross-section. The offices of the tube 75 are not limited to those above mentioned as it also serves as a main assembly shaft, as a locking member for preventing inadvertent separation of the assembled parts, and also carries ports for all valves used in the motor, acts as a "breather" means for the contents of the chamber formed within the element 166, and acts as a guide for causing proper registration of ports.

Attention is particularly directed to the fact that the element 75 must in all instances be designed and built for a unit composed of a specific number of motor pistons and piston chambers, as well as for each desired length of piston stroke. This is due to the shape of the element 75. Additional power units cannot be added to or removed from a unit designed to be composed of any particular number of motor pistons and chambers. However, the unit may be designed to give the desired power at a given pressure by one or more power pistons and chambers.

Obviously the invention is susceptible of embodiment in forms other than that which is illustrated in the accompanying drawings and described herein, and applicable for uses and purposes other than as detailed, and I therefore consider as my own all such modifications and adaptations and other uses of the form of the device herein described as fairly fall within the scope of my invention.

Having thus described my invention, what is claimed and desired to be secured by Letters Patent, is:

1. In a fluid driven motor-pump for bored wells, the combination with a piston chamber having a cylinder head at each of its ends, and with a piston rod and piston reciprocatably mounted within the chamber, of a stationary combination delivery tube for power fluid and exhaust tube for used power fluid, said piston rod slidably mounted upon the tube and held against rotation with relation thereto, ports in the tube, other ports in the piston, and a reciprocal valve carried by the piston and controlling flow of fluid from the tube to the chamber and from the chamber to the tube, for causing reciprocation of the piston.

2. In a fluid driven motor-pump for bored wells, the combination with a piston chamber having a cylinder head at each of its ends, and with a piston reciprocatably mounted within the chamber, of a hollow piston rod connected to

the piston, and a stationary delivery tube within the piston rod, said tube having a pair of longitudinal passages therethrough, one for piston motive fluid and one for exhaust piston motive fluid, said rod and tube having co-operating ports affording communication between the interiors of the tube and piston chamber.

3. Organization as described in claim 1, and fluid means for stopping the valve at each end of its stroke.

4. In a fluid driven motor-pump, the combination with a reciprocatable piston within a housing, of a hollow stationary tube passing through the piston, a longitudinally extending partition within the tube dividing it into a power fluid delivery passage and a used power fluid exhaust passage, a hollow piston rod carrying the piston and slidably mounted around the tube and held in a fixed radial position with relation thereto, means carried by the piston for controlling the flow of a power fluid from the delivery passage to reciprocate the piston, and means carried by the piston for controlling the flow of used power fluid to deliver it into the exhaust passage in timed relation to the action of the piston.

5. In a fluid driven motor-pump, the combination with a reciprocatable piston, a housing therefor forming a piston chamber, said chamber being closed at each end, of a hollow stationary tube passing through the piston, a longitudinally extending partition within the tube dividing it into a power fluid delivery passage and a used power fluid exhaust passage, a hollow piston rod carrying the piston and slidably mounted around the tube and held in fixed radial position with relation thereto, means for simultaneously delivering a power fluid from the delivery passage to one end of the chamber and for simultaneously exhausting used power fluid from the other end of the chamber into the exhaust passage for causing the piston to move in one direction, and means for changing the flow of power fluid to the said other end of the chamber and simultaneously changing the flow of used power fluid to the exhaust passage from the opposite end of the chamber at each end of each stroke of the piston to alter the piston's direction of travel.

6. In a fluid driven motor-pump, the combination with a reciprocatable piston, a housing therefor, and a closed ended compression chamber at each end of the permitted stroke of the piston, of a hollow stationary tube passing through the piston, a longitudinally extending partition within the tube dividing it into a power fluid delivery passage and a used power fluid exhaust passage, a hollow piston rod carrying the piston and slidably mounted around the tube and held in fixed radial position with relation thereto, ports carried by the tube within the piston at each side of the partition therein, a port carrying sleeve carried by the piston for opening and closing the ports in the tube, a port carrying sleeve valve slidably supported within the piston, and other ports carried by the piston and communicating with the chambers, said valve controlling flow of fluid from the power passage to the chambers and the flow of fluid from the chambers to the exhaust passage in a manner causing reciprocation of the piston.

7. In a fluid driven motor-pump, the combination with a reciprocatable piston, a housing therefor forming a piston chamber, said chamber being closed at each end, of a hollow stationary tube passing through the piston, a longitudinally extending partition within the tube dividing it into a power fluid delivery passage and a used power fluid exhaust passage, a hollow piston rod carrying the piston and slidably mounted around the tube and held in fixed radial position with relation thereto, ports carried by the tube within the piston at each side of the partition therein, a port carrying sleeve carried by the piston, a port carrying sleeve valve slidably supported within the piston for opening and closing the ports in the tube, other ports carried by the piston and communicating with the chambers, said valve controlling flow of fluid from the power passage to the chambers and the flow of fluid from the chambers to the exhaust passage, and fluid pressure means for shifting the valve at each stroke of the piston for causing the piston to reciprocate.

8. Organization as described in claim 7, in which the last mentioned means includes: ports carried by the tube at each side of its partition adjacent the positions the piston assumes at the ends of its stroke; and other ports carried by the port carrying sleeve and adapted to register with the ports in the tube, said other ports communicating with the space within which the sleeve valve travels.

9. In a fluid driven motor-pump, the combination with a piston and piston chamber, and with a power fluid delivery line and a motor exhaust line, of valve means for permitting the flow of power fluid into the chamber at one end of the piston, before cutting off the flow of power fluid into the chamber at the opposite end of the piston, and for permitting the flow of exhaust fluid from the chamber at one end of the piston, before cutting off flow of exhaust fluid from the chamber at the opposite end of the piston.

10. In a fluid driven motor-pump, the combination with a reciprocatable pump-piston, a motor-piston, a hollow piston rod connecting the two, a piston chamber for each piston, and a sleeve connected to the free end of the motor-piston, extending from its piston chamber and terminating within a separate closed ended chamber, of a hollow stationary standing tube passing through the pistons, the piston rod, and the sleeve, and terminating within the closed ended chamber beyond the stroke of the sleeve, said standing tube having ports near its lower end affording communication between its interior and said closed ended chamber, and also having ports near its upper end affording communication between its interior and the delivery end of said pump piston chamber, whereby the pressures within the pump piston chamber, the tube, and the closed ended chamber are equalized during the reciprocation of the pistons and the sleeve.

11. In a fluid driven motor-pump for bored wells, the combination with a piston and a piston chamber, of a stationary delivery tube for delivering piston motive fluid to the chamber, and a stationary exhaust tube for exhausting used piston motive fluid from the chamber, both of said tubes extending within the chamber from one end thereof to a point lying beyond the most remote end of the permitted stroke of the piston.

12. In a fluid driven motor for deep wells, the combination with a plurality of motor piston heads, and chambers in which they operate, of a piston rod connecting said heads, said piston rod affording passage for piston motive fluid,

and fluid pressure actuated means for simultaneously delivering a fluid from the rod to similar ends of each of the heads.

13. In a fluid driven motor pump the combination with a pump piston and chamber, of a plural number of motor piston chambers; a motor piston slidably mounted in each chamber; a piston rod connecting the motor pistons and the pump pistons; a means passing through each piston chamber and conveying the supply of motive fluid to said motor piston chambers, and a means passing through each piston chamber for conveying exhaust motive fluid from said motor piston chambers.

14. In a fluid driven motor-pump, the combination with a motor piston-chamber, a motor-piston reciprocatably mounted within the chamber, a motive fluid line, a motive fluid exhaust line, both lines having ports for communicating with the chamber, and with a piston-rod connected to said motor-piston, of a pump piston chamber, a pump-piston within said chamber and connected to said piston-rod, said pump piston-chamber situated above said motor piston-chamber, said fluid conveying lines passing through said pump piston chamber.

15. In a fluid driven motor pump the combination with a pump piston and chamber, of a fluid driven motor including a plural number of motor piston chambers; a piston slidably mounted in each chamber, a control valve for controlling power fluid to and from each piston; a piston rod connecting the motor pistons and the pump piston; and a means passing through each piston chamber for conveying a fluid for actuating the control valve.

16. In a fluid driven motor-pump, the combination with a motor piston, and a chamber within which it reciprocates, of a ported valve carried by the piston, ports also carried by the piston, and stationary means within the piston rod for conveying a fluid to the ports for causing a timed shifting of the valve for controlling a piston motive fluid.

17. In a fluid driven motor pump, the combination with a motor piston, a motor piston chamber, and with a power fluid delivery line, of valve means carried by said piston for controlling the flow of motive fluid to opposite sides of said piston within the chamber, and adapted to direct the flow of power fluid into the chamber at one end of the piston before cutting off the flow of power fluid into the chamber at the opposite end of the piston.

18. In a fluid driven motor-pump for bored wells, the combination with a piston head reciprocatably mounted within a piston chamber, of a hollow piston rod connected to the piston head, stationary means within the rod for conveying a piston motive fluid to said head, and means for alternately delivering the fluid from the said means to the chamber at opposite ends of the piston head.

19. In a fluid driven motor pump for deep wells, the combination with a piston chamber having a cylinder head at each of its ends, and a piston reciprocatably mounted within the chamber, of: a hollow piston rod connected to the piston; a stationary delivery tube for piston motive fluid within the piston rod, said tube having ports for communicating with the chamber; a valve for controlling the flow of motive fluid from the tube, and including the piston which slides along the tube and acts as a timing mechanism to control the shifting of the control valve.

20. In a fluid driven motor pump for deep wells, the combination with a piston chamber having a cylinder head at each of its ends, and with a piston reciprocatably mounted within the chamber, of: a hollow piston rod connected to the piston; a stationary delivery tube for exhaust piston motive fluid within the piston rod, said tube having ports for communicating with the chamber; and a valve for controlling the flow of exhaust fluid into the tube, and including the piston which slides along the tube and acts as a timing mechanism to control the shifting of the control valve.

21. In a fluid driven motor pump for deep wells, the combination with a piston chamber having a cylinder head at each of its ends, and a piston reciprocatably mounted within the chamber, of: a hollow piston rod connected to the piston; a stationary delivery tube for piston motive and exhaust piston motive fluid within the piston rod, said rod and tubes having ports for communication with said chamber; and a valve for controlling flow of the fluid into and out of the tubes, and including the piston which slides along the tube and acts as a timing mechanism to control the shifting of the control valve.

22. In a fluid driven motor pump for deep wells, the combination with a piston chamber having a cylinder head at each of its ends, and a piston reciprocatably mounted within the chamber, of: a hollow piston rod connected to the piston; and a stationary delivery tube for piston motive and exhaust piston motive fluid within the piston rod, said tubes being provided with ports affording communication between the tubes and the chamber, said ports being of a length substantially equal to the length of the piston stroke.

23. In a fluid driven motor pump for deep wells, the combination with a hollow tube connected to a source of fluid pressure and extending from the earth's surface into the well for delivering motive fluid to said motor pump, of: a stationary longitudinally partitioned hollow tube having one of its longitudinal passages in communication with said delivery tube; a cylinder surrounding the partitioned tube; a piston surrounding said partitioned tube and reciprocable in the cylinder by fluid pressure alternately supplied to opposite ends of said cylinder through properly spaced ports in the delivery passage of said partitioned tube; a control valve within the piston for controlling the flow of motive fluid from the delivery tube into the opposite ends of the cylinder in timed relation to the piston movement, and for controlling the exhaust of used piston motive fluid from the opposite ends of the cylinder through properly spaced ports into the other of the passages of said partitioned tube in timed relation to the piston movement.

24. In a fluid driven motor pump, the combination with a pump including a cylinder, a pump piston reciprocable in the cylinder, an inlet and an outlet for the cylinder, and a string of production tubing in communication with the outlet, of: a motor cylinder; a motor piston reciprocable therein by fluid pressure alternately supplied to opposite ends of the cylinder; a hollow piston rod extending from the pump cylinder into the motor cylinder and connected to both the pump and motor pistons; a stationary longitudinally partitioned tube within the piston rod having a motive fluid delivery passage in communication with a remote source of fluid pressure supply and with the interior of the motor cylin-

der, and having a motive fluid exhaust passage in communication with said motor cylinder and said production tubing; and valve means for simultaneously and equi-proportionately cutting off the flow of exhaust piston motive fluid from and permitting the flow of motive fluid into one end of the motor cylinder, and for simultaneously and equi-proportionately cutting off the flow of piston motive fluid into and permitting the flow of exhaust piston motive fluid out of the opposite end of the motor cylinder.

25. In a fluid driven motor-pump, the combination with a piston chamber closed at each of its ends, a piston reciprocatably mounted in the chamber, and with a piston motive fluid delivery line and a used piston motive fluid exhaust line, of: intake and exhaust valve means associated with said delivery and exhaust lines for simultaneously, and equi-proportionately, cutting off the flow of exhaust piston motive fluid from and affording flow of piston motive fluid into the chamber at one end of the piston, and for simultaneously, and equi-proportionately, cutting off the flow of piston motive fluid to and affording flow of exhaust piston motive fluid from the chamber at the opposite end of the piston, said valve means adapted to provide constant flow of the motive fluid from the delivery line into the piston chamber, and constant flow of exhausting fluid from the piston chamber into said exhaust line, regardless of the direction of piston travel and regardless of the location of the piston in the chamber, thus eliminating the cause of fluid shock or water hammer, i. e. the complete though instantaneous stoppage of the fast moving motive fluid.

26. In a unitary fluid driven motor-pump, the combination with a motor piston and cylinder therefor, with a pump piston and cylinder therefor, with a single hollow piston rod connecting both pistons together, with a central stationary hollow tube slidably fitted within said piston rod and on which said pistons and piston rod are adapted to reciprocate, said tube having two separate longitudinal passages therein, one for power fluid delivery and one for used power fluid exhaust, and with co-operating spaced through ports in both the tube passage walls and in said hollow piston rod walls for conducting power fluid into each end of the motor cylinder and for conducting used power fluid out of each end of the motor cylinder, of: a valve for controlling the flow of power fluid through certain ones of said ports into each end of the motor cylinder and for controlling the exhaust of used power fluid through certain ones of said ports out of each end of the motor cylinder; said valve being so constructed with relation to the co-operating ports in said tube passages and piston rod that, as the pistons reciprocate, power fluid begins to flow from the fluid delivery passage in said tube into the first end of the motor cylinder ahead of the approaching piston before fluid ceases to flow from said fluid delivery passage into the second end of the motor cylinder behind the receding piston, and exhaust motive fluid simultaneously begins to flow from the second end of the motor cylinder into the exhaust passage of said tube behind the receding piston before the exhaust motive fluid ceases to flow from the first end of said motor cylinder ahead of the approaching piston, thus eliminating complete stoppage of motive fluid from the delivery passage and used motive fluid into the exhaust passage of said tube; and means controlled by the motor piston as it reciprocates for actuating said valve.

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