June 1, 1954 R. L. CHENAULT 2,679,806

HYDRAULIC SUBSURFACE MOTOR AND PUMP COMBINATION

Filed March 27, 1952 4 Sheets-Sheet 1

FIG. 2.

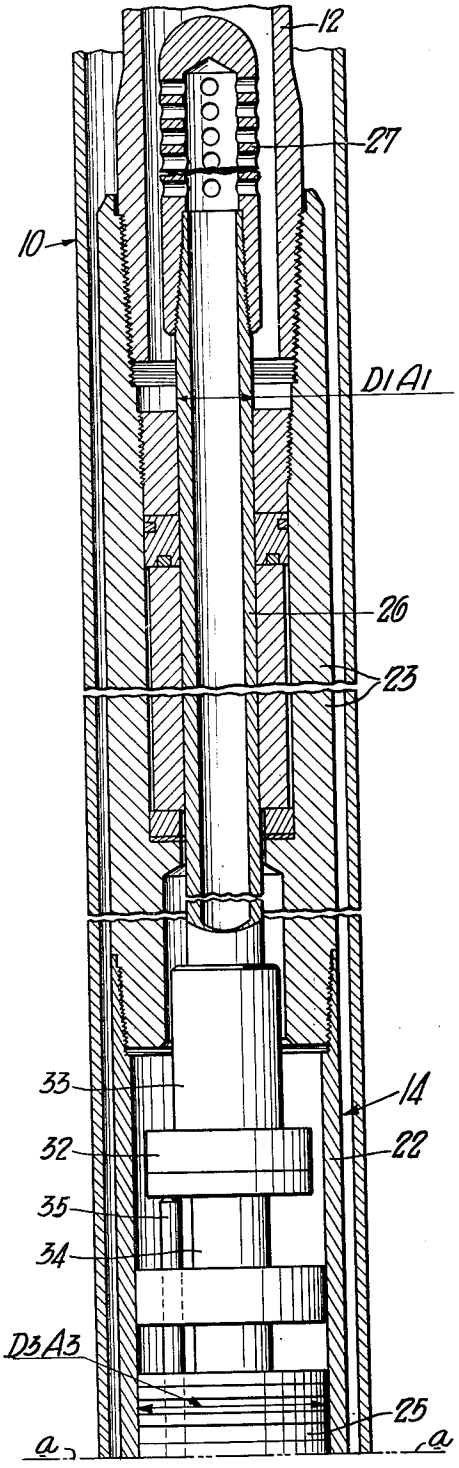
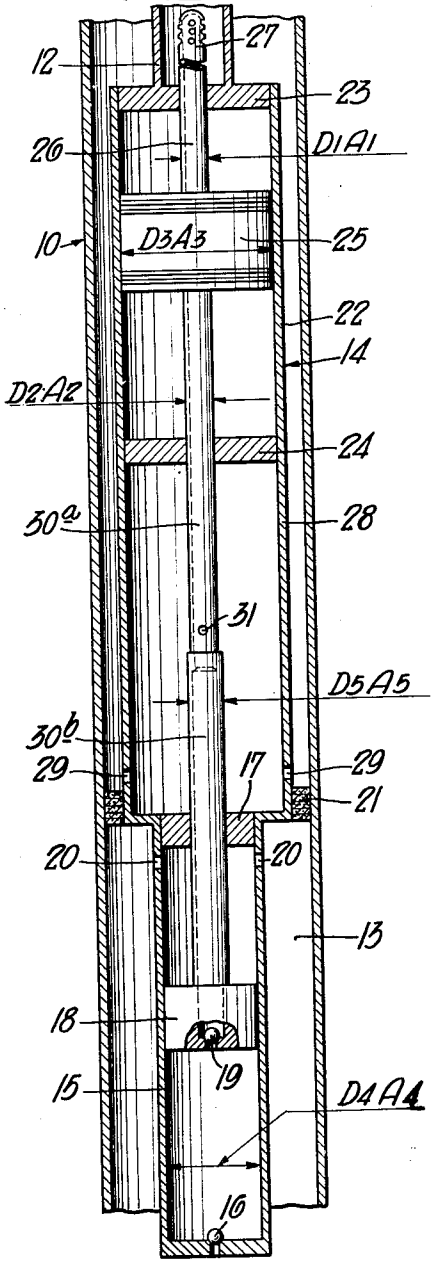


FIG. 1.



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HYDRAULIC SUBSURFACE MOTOR AND PUMP COMBINATION

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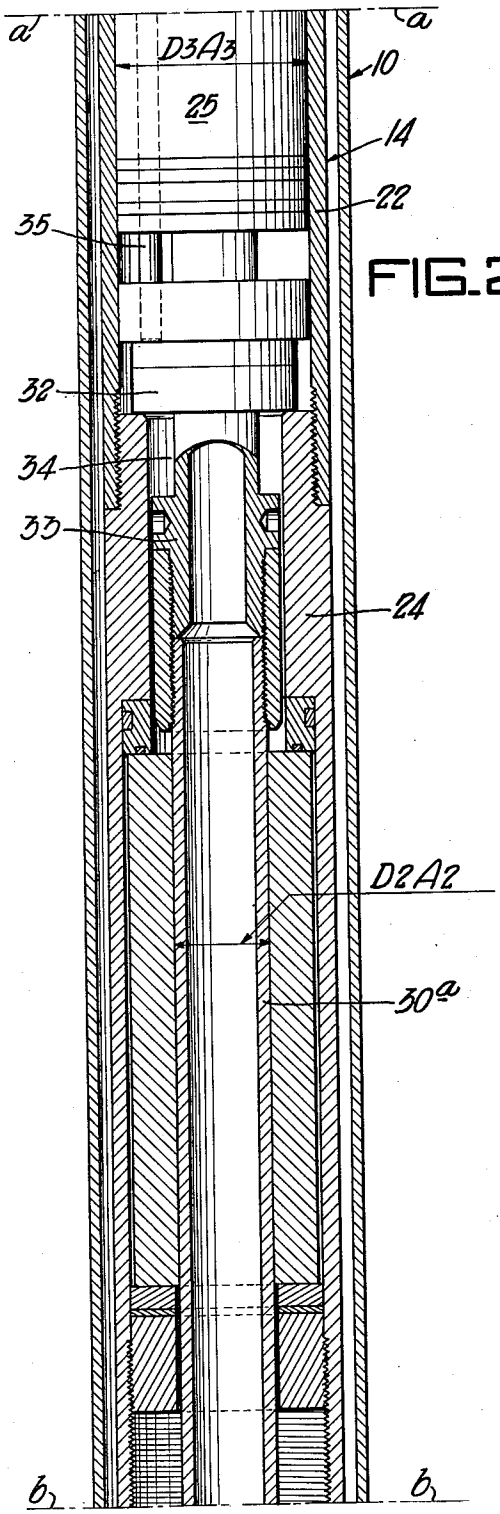


FIG. 2a

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HYDRAULIC SUBSURFACE MOTOR AND PUMP COMBINATION

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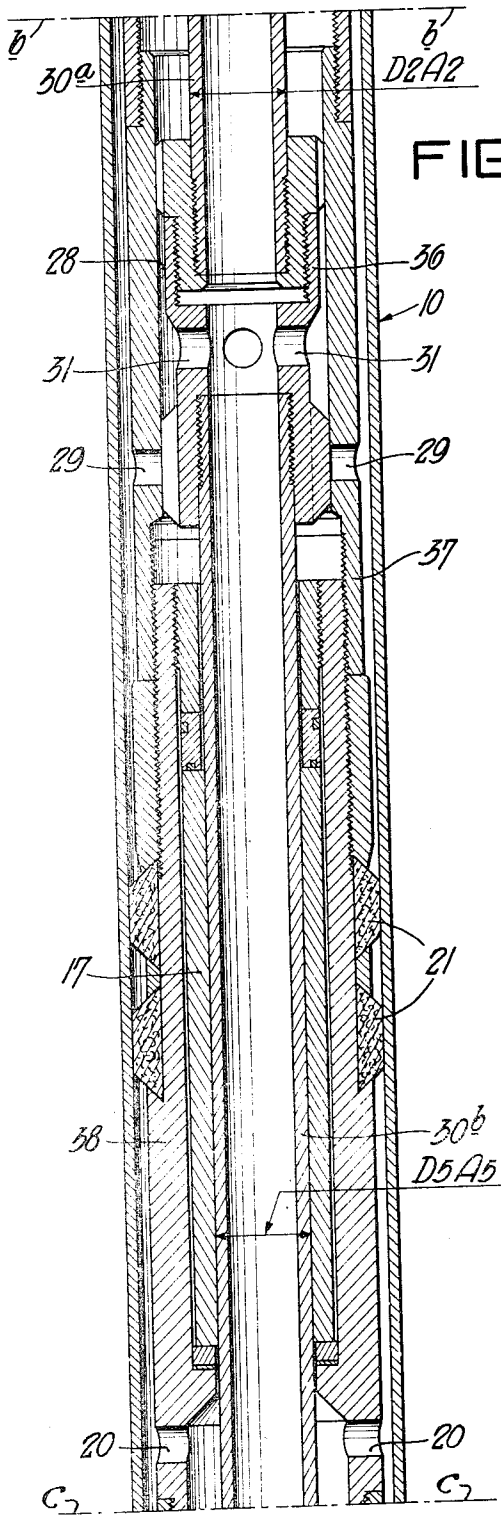


FIG. 2b.

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HYDRAULIC SUBSURFACE MOTOR AND PUMP COMBINATION

Filed March 27, 1952 4 Sheets-Sheet 4

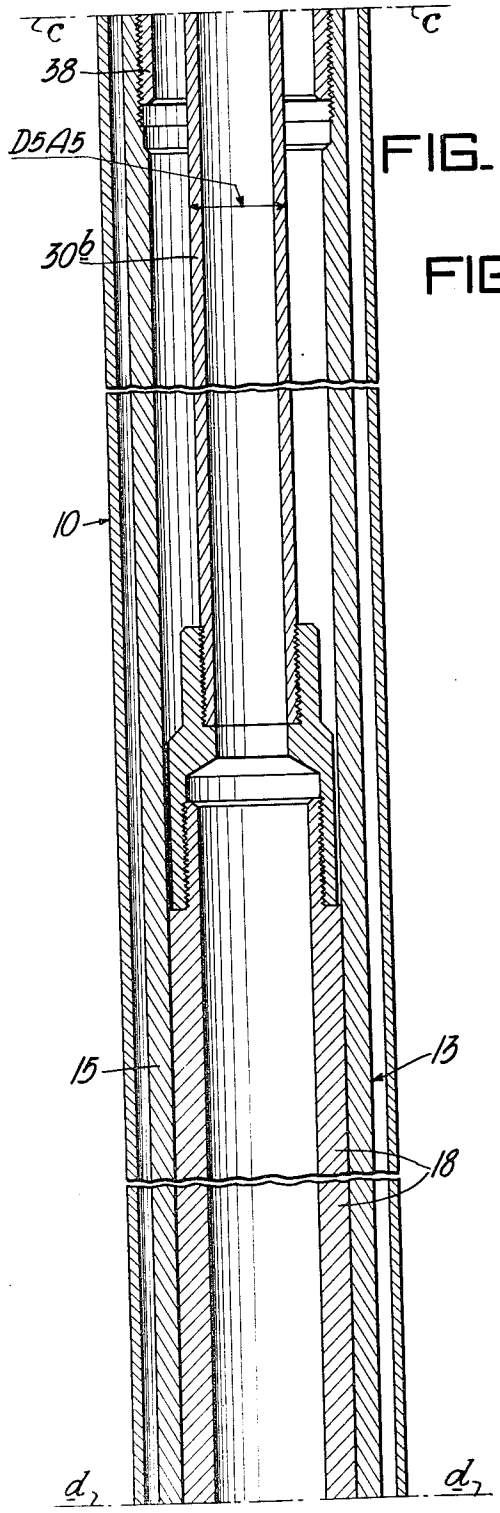


FIG. 2c.

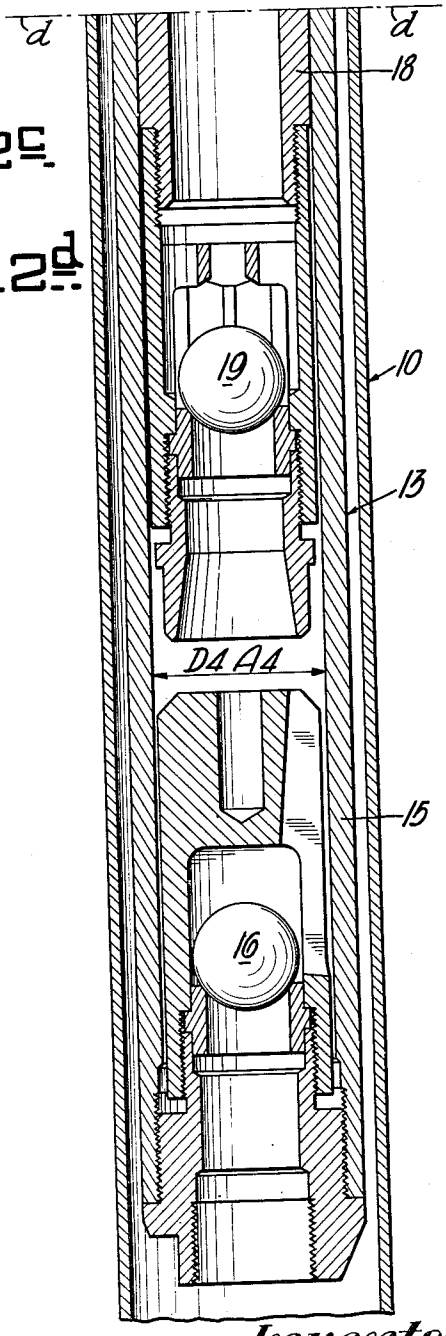


FIG. 2d.

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UNITED STATES PATENT OFFICE

2,679,806

HYDRAULIC SUBSURFACE MOTOR AND PUMP COMBINATION

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Application March 27, 1952, Serial No. 278,853

2 Claims. (Cl. 103—46)

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This invention relates to a hydraulic subsurface motor and pump combination, and more specifically to improvements in that shown in my earlier Patent No. 2,191,369, dated February 20, 1940.

Such combinations are refered to in the art as "rodless pumps" and can be used for pumping oil wells in lieu of the more common sucker rod pumps. A rodless pump is installed near the bottom of a well and its motor is actuated by a stream of oil pumped down the well. The motor conventionally includes a barrel, a piston reciprocable therein and joined to the reciprocable element of the pump, a main valve for alternately applying power oil to opposite ends of the piston for producing upstrokes and downstrokes, and usually a pilot valve for operating the main valve at the ends of the piston strokes. The important novel feature of my earlier patent is that both the main valve and pilot valve are housed within the motor piston, thereby dispensing with longitudinal passages in the walls of the motor barrel. Such passages not only are difficult and costly to form, but they necessitate thicker walls. Pumps of this sort must be installed in tubing of limited cross sectional dimensions, commonly a two inch inside diameter. Consequently all space occupied by the barrel walls is at the expense of piston area.

My earlier patent shows a double-acting pump, that is, a pump with inlet and discharge valves at both ends of its barrel. Such a pump must have longitudinal passages in the barrel walls, but was used to balance the load on the motor on its up and down strokes. Single-acting pumps are simpler and have become standard for sucker rod installations. They do not require longitudinal passages in the barrel walls, but ordinarily they deliver fluid only during the stroke in one direction and their power requirements on the two strokes are unbalanced. These difficulties generally have precluded their use in rodless installations. Nevertheless the greater piston area possible because of the absence of longitudinal wall passages assures that the capacity of a single-acting pump of given outside diameter is at least as great as that of a double-acting pump.

An object of the present invention is to provide an improved hydraulic rodless pump combination which altogether eliminates longitudinal

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passages in the barrel walls, both in the motor and the pump, and yet has a balanced load on the motor on both strokes.

A further object of the invention is to provide such a combination wherein the pump is single-acting and can be of standard manufacture identical with those used in sucker rod installations.

The recently patented art in rodless pumps shows a trend toward increasing complexity, which of course increases manufacturing and maintenance costs. A further object of the present invention is to provide a rodless pump combination of greatly simplified construction without impairing its performance.

In accomplishing these and other objects of the invention, I have provided improved details of structure, a single form of which is shown in the accompanying drawings, in which:

Figure 1 is a schematic vertical sectional view of a motor and pump combination embodying features of the present invention; and

Figures 2, 2*a*, 2*b*, 2*c* and 2*d* together are a vertical sectional view of an actual construction of motor and pump in accordance with the invention.

Figure 1 shows a hydraulic subsurface motor and pump combination constructed in accordance with the present invention, but in a form much simplified over actual installations, and not to scale, to illustrate the principles more clearly. The combination comprises a conventional well tubing 10, a smaller power fluid delivery tube 12 therein, a single acting pump 13, and a hydraulic motor 14. Pump 13 includes a barrel 15, a standing valve 16 and a cylinder head 17 at the bottom and top respectively of said barrel, a reciprocable element 18 within said barrel, and a traveling valve 19 carried by said reciprocable element. For simplicity Figure 1 shows the reciprocable element as a piston, although a plunger more likely would be used, as shown in Figures 2*c* and 2*d*. The upper part of barrel 15 has relief ports 20. Exterior sealing means 21 seals the top of the pump barrel from the inside of the tubing 10. Motor 14 is similar to that shown in my earlier patent and includes a barrel 22, which is spaced inside the tubing 10 and has upper and lower cylinder heads 23 and 24, and a piston 25 mounted for reciprocable movement in said barrel.

In common with my earlier patent, an upper

tubular piston rod 26 extends upwardly from the motor piston 25, through a bore in the upper cylinder head 23 and into the power fluid delivery tube 12. The upper end of this piston rod has openings 27 for admitting power fluid from tube 12 into the rod and thence into motor 14. The motor piston 25 contains main and pilot valves which direct such fluid alternately to opposite ends of the motor cylinder so that the piston moves up and down. These valves and the associated passages in the piston are not shown in Figure 1, but reference can be made to my earlier patent for a complete showing. A fluid receiving chamber 28 is situated between pump 13 and motor 14 and has delivery ports 29 that are situated above the sealing means 21 and lead into the annular space between the chamber wall and the inside of tubing 10. A tubular lower piston rod composed of sections 30*a* and 30*b* extends downwardly from the motor piston 25, through a bore in the lower cylinder head 24, the chamber 28, a bore in the pump cylinder head 17, and into the pump barrel 15, where it is joined to the pump piston 18. Said lower piston rod contains a discharge port 31 for discharging both fluid raised by the pump and exhaust power fluid from the motor into the chamber 28.

In operation, a stream of power fluid is pumped down the power fluid delivery tube 12 and reaches the motor 14 via the upper piston rod 26. This fluid alternately raises and lowers the motor piston 25 by operation of the valves therein, which are not shown as already explained. The power fluid exhausts from the motor through the upper section 30*a* of the lower piston rod and its port 31 into chamber 28. The lower piston rod 30*a*, 30*b* transmits reciprocable movement of the motor piston to the pump piston 18.

During an upstroke of piston 18, the standing valve 16 opens and the traveling valve 19 closes, and the piston draws fluid from the well into the lower part of the pump barrel 15. The space in the barrel above the piston 18 is relieved to the well via ports 20. During a downstroke the positions of the two valves reverse and fluid in the lower part of the pump barrel is forced up the section 30*b* of the lower piston rod and through port 31 into chamber 28. The exhaust power fluid from the motor and the well fluid thus blend within this chamber. As these fluids are introduced to the chamber they force fluid through ports 29, up tubing 10 to the surface.

It is seen that construction just described altogether eliminates longitudinal passages in the walls of the tubing 10, the motor and pump barrels 15 and 22 and the receiving chamber 28. The problem remaining is to attain a balanced load on the motor on both its upstroke and its downstroke. The combination shown in my earlier patent successfully eliminates longitudinal passages in the walls of the motor barrel, but requires a double-acting pump to attain a balanced load. A double-acting pump of course has longitudinal passages in its barrel walls. The present invention both attains the necessary balance and dispenses completely with longitudinal wall passages by proper proportioning of certain critical diameters and cross sectional areas.

To explain the proportioning I designate the critical diameters and cross sectional areas as follows:

D_1 and A_1, outside diameter and cross sectional area respectively of the upper piston rod 26;

D_2 and A_2, outside diameter and cross sectional area respectively of the upper section 30*a* of the lower piston rod;

D_3 and A_3, outside diameter and cross sectional area respectively of the motor piston 25;

D_4 and A_4, inside diameter and cross sectional area respectively of the pump barrel 15; and

D_5 and A_5, outside diameter and cross sectional area respectively of the lower section 30*b* of the lower piston rod.

The foregoing designations are indicated on Figure 1.

On the downstroke the effective area on which the power fluid acts is represented by A_3, or the total cross sectional area of the motor piston 25, since the power fluid acts downwardly against the top of rod 26 as well as against the actual top of the piston. The displacement area from the motor discharge is represented by A_3-A_2, or the cross sectional area of the motor piston 25 less that of the section 30*a* of the lower piston rod. The displacement area from the pump discharge is represented by $A_4-(A_5-A_2)$ or the cross sectional area of the pump barrel 15 less the difference between the cross sectional areas of the two segments 30*a* and 30*b* of the lower piston rod.

On the upstroke the effective piston area for the power fluid is represented by $A_3-(A_2+A_1)$ which is the cross sectional area of the motor piston 25 less the cross sectional areas of both the upper piston rod 26 and the upper segment 30*a* of the lower piston rod. It is seen that the power fluid in tube 12 continuously acts downwardly against the top of the upper piston rod 26, thus diminishing the effective piston area during an upstroke by this further area A_1 in addition to the loss of piston area caused by the presence of the lower piston rod 30*a*. The effective displacement area from the motor discharge is A_3-A_1 or the cross sectional area of the motor piston 25 less that of the upper piston rod 26. The effective displacement area from the pump discharge is A_5-A_2 or the difference between the cross sectional areas of the two segments 30*a* and 30*b* of the lower piston rod. The upper face of the reciprocable element 18 of the pump is ineffective since it is subjected only to the static pressure of the fluid in the reservoir from which it is pumped.

To attain a perfect hydraulic balance the ratio of effective power piston area to the displacement area must be the same on both the upstroke and the downstroke; that is

$$\frac{\text{Effective power piston area}}{\text{Displacement area from motor} + \text{displacement area from pump}}$$

must be the same on each stroke. Consequently the critical dimensions must be proportioned such that

$$\frac{A_3}{(A_3-A_2)+A_4-(A_5-A_2)}=\frac{A_3-(A_2+A_1)}{A_3-A_1+(A_5-A_2)}$$

in which the quantity at the left represents the ratio on the downstroke and the quantity at the right the ratio on the upstroke. An example of dimensions which furnish a balanced load is as follows:

$D_1=\frac{13}{16}$ in.	$A_1=0.518$ sq. in.
$D_2=1.02$ in.	$A_2=0.817$ sq. in.
$D_3=1\frac{7}{8}$ in.	$A_3=2.76$ sq. in.
$D_4=1\frac{3}{4}$ in.	$A_4=2.41$ sq. in.
$D_5=1.02$ in.	$A_5=0.817$ sq. in.

In this example D_2 and D_5 are equal and their difference is nil; however this condition is not necessarily true. Substituting in the above equation:

$$\frac{2.76}{(2.76-0.817)+2.41-(0.817-0.817)}=\frac{2.76-(0.817+0.518}{2.76-0.518+(0.817-0.817)}$$

$$0.635=0.635$$

Figures 2 to 2*d* show a practical construction of motor and pump that embodies the present invention, that is, a motor and pump which are practical for actual installations. The parts are designated by the same reference numerals as in Figure 1, and the description of that figure applies as well to Figures 2 to 2*d*, so that it need not be repeated.

However, I have shown upper and lower operating devices for the pilot valve that differ slightly from those shown in my earlier patent and are more practical because of the space limitations. The upper and lower operating devices are shown in Figures 2 and 2*a* respectively and are alike so that a description of one serves for both. Each operating device includes a ring or collar **32** slidably mounted on a projection **33** of the motor piston. Said projection has a circumferential groove **34** within which said collar slides, and the ends of said groove form stops that limit movement thereof. The end of the pilot valve slide, designated **35**, abuts collar **32** which in turn is adapted to engage the inside of the upper or lower cylinder head **23** or **24**. Thus it is unnecessary to proportion the parts so that the pilot valve slide must engage the cylinder heads directly, as in my earlier patent.

The pump **13** shown in Figures 2*c* and 2*d* preferably is of standard design identical with pumps used in sucker rod installations. In this instance the reciprocable element **18** is a plunger. It is necessary merely to select a pump whose barrel **15** has an inside diameter in proper ratio to the other critical dimensions. The two sections **30***a* and **30***b* of the lower piston rod are rigidly connected by a coupling **36** which contains the ports **31** (Figure 2*b*). The pump barrel **15** and motor barrel **22** are rigidly connected by an assembly formed of the lower cylinder head **24** of the motor, and tubular couplings **37** and **38** (Figure 2*b*). The space within these latter couplings constitutes the chamber **28**. The packing **21** is on the exterior of coupling **38**.

From the foregoing description it is seen that the present invention affords a hydraulic motor and pump combination that is completely balanced and yet altogether eliminates vertical passages in the barrel walls, both in the motor and the pump. The combination is of simple construction and makes maximum utilization of standard parts.

While I have shown and described only a single embodiment of the invention, it is apparent that modifications may arise. Therefore, I do not wish to be limited to the disclosure set forth but only by the scope of the appended claims.

I claim:

1. A subsurface hydraulic motor and pump combination comprising tubular pump and motor barrels, cylinder heads at both ends of said motor barrel and at the upper end of said pump barrel, tubular coupling means joining the upper end of said pump barrel and the lower end of said motor barrel and furnishing a fluid receiving chamber therebetween, said barrels and said coupling means being free of longitudinal wall passages, a standing valve at the lower end of said pump barrel, a plunger reciprocable in said pump barrel, a traveling valve carried by said plunger, a relief port in said pump barrel above said plunger, a piston in said motor barrel, a tubular upper piston rod extending upwardly from said piston through the cylinder head at the upper end of said motor barrel for delivering power fluid to the motor, a tubular lower piston rod connecting said piston and said plunger and having a discharge port in said chamber, main and pilot valves housed in said piston, said coupling means having a discharge port from said chamber, and exterior sealing means between said last named discharge port and said relief port, the cross sectional areas of said pump barrel, said piston and said piston rods being proportioned to furnish the same ratio of effective power piston area to total displacement area on both the upstroke and downstroke of the parts.

2. A combination as defined in claim 1 in which the cross sectional areas are proportioned according to the formula:

$$\frac{A_3}{(A_3-A_2)+A_4-(A_5-A_2)}=\frac{A_3-(A_2+A_1)}{A_3-A_1+(A_5-A_2)}$$

wherein A_1 is the cross sectional area of said upper piston rod, A_2 of said lower piston rod adjacent said piston, A_3 of said piston, A_4 of said pump barrel, and A_5 of said lower piston rod adjacent said plunger.

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2,191,369	Chenault	Feb. 20, 1940
2,291,880	Coberly	Aug. 4, 1942
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