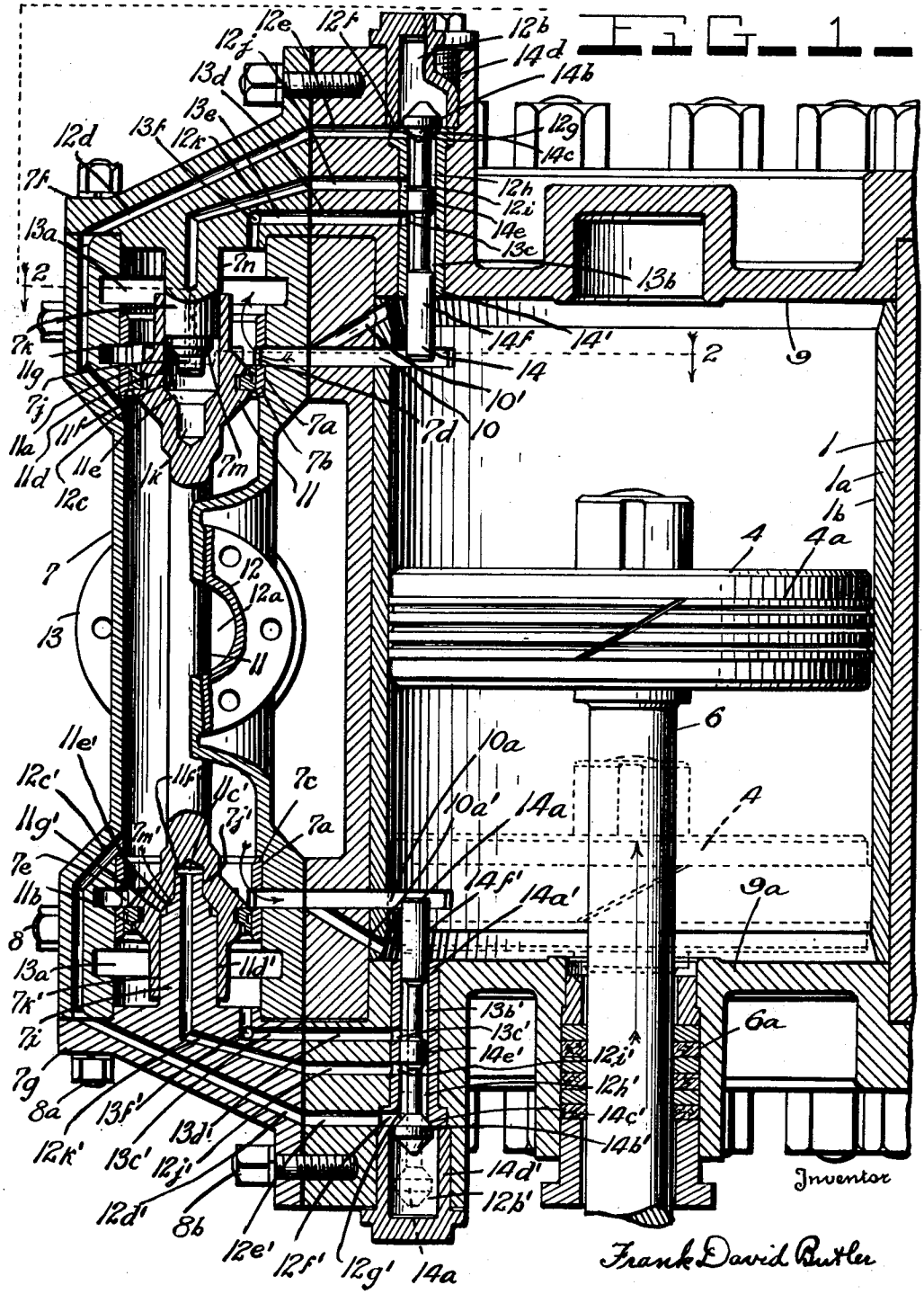
Dec. 19, 1939. F. D. BUTLER 2,183,538

EXPANSIVE FLUID-ACTUATED PILOT-CONTROLLED VALVE MECHANISM FOR MOTORS OF RECIPROCATING PUMPS

Filed Jan. 21, 1938 3 Sheets-Sheet 1

FIG. 1



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Filed Jan. 21, 1938 3 Sheets-Sheet 2

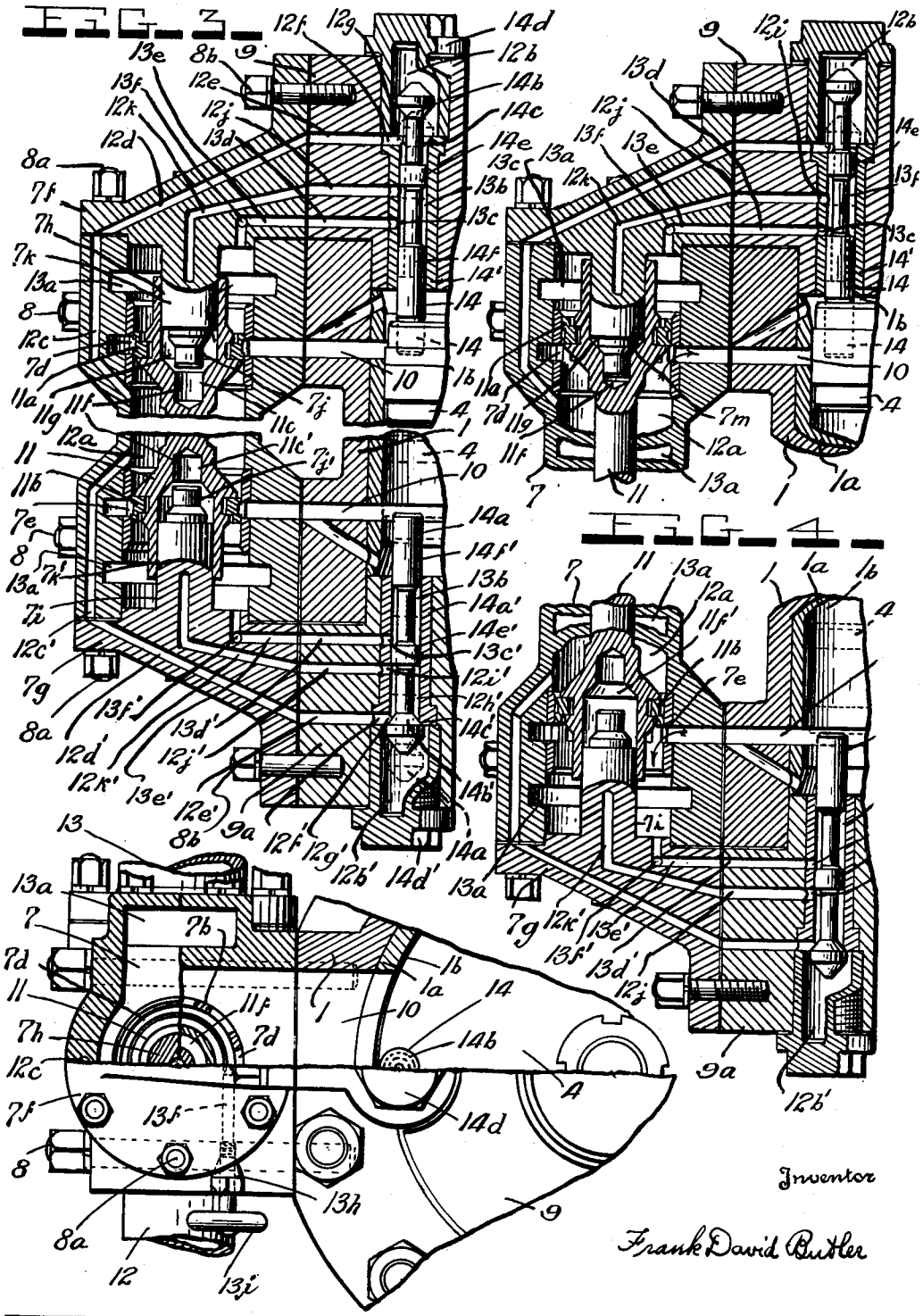

FIG. 2

FIG. 4

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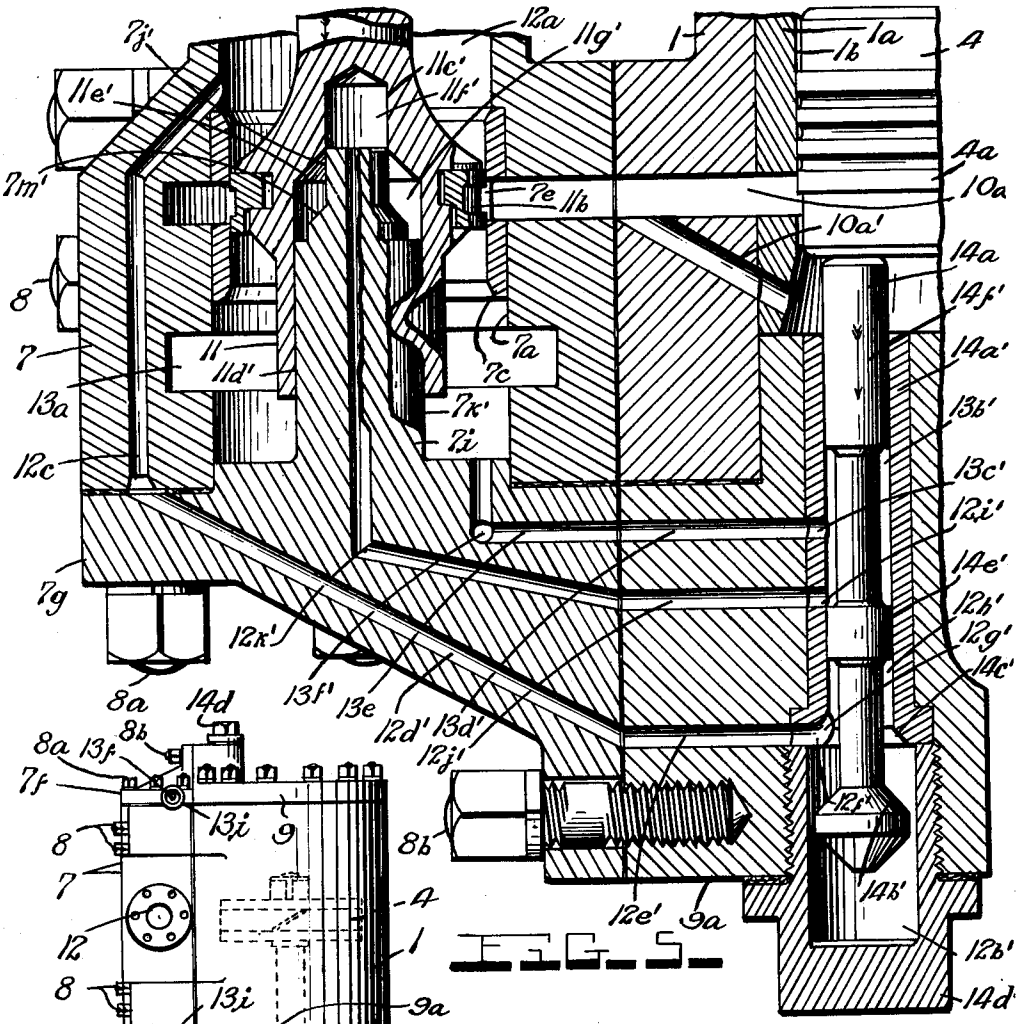

Inventor

Frank David Butler

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2,183,538

EXPANSIVE FLUID-ACTUATED PILOT-CONTROLLED VALVE MECHANISM FOR MOTORS OF RECIPROCATING PUMPS

Frank David Butler, United States Navy

Application January 21, 1938, Serial No. 186,058

8 Claims. (Cl. 121—157)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

My present invention relates to valve operating mechanisms for motors of reciprocating pumps wherein the pilot valve or valves of such a motor is mechanically operated either directly or indirectly by the main piston and wherein the main valve of such motor is actuated by expansive fluid which latter is controlled by such pilot valve or valves.

The major concept of my present invention is the provision of a simple, compact, efficient, durable and relatively inexpensive valve assembly for the type of motor mentioned.

More specific concepts of my invention contemplate the following features:

The provision of a spool shaped main valve member which is adapted to be slidably mounted within a cylindrical bore of a suitable valve chest located adjoining the cylinder of the motor, the main valve member to have a plurality of cylindrical shaped fluid actuating chambers for the purpose of alternately containing the expansive fluid for actuating the main valve, one being located adjoining each end thereof and both having a plurality of diameters with a seat interposed between the plurality of diameters;

The provision of a pair of valve chest bore covers, one for each end of the valve chest bore, both having suitable shoulder projections extending inward in said valve chest bore and adapted to support said main valve centrally within said bore;

The projection of each of such covers having a plurality of diameters with a suitable shoulder seat portion interposed between such plurality of diameters and corresponding to the plurality of diameters and interposed seats therebetween of the fluid actuating chambers of said main valve;

The provision of a pair of elongated cylindrical shaped pilot valve members slidably mounted parallel to the bore of the main motor cylinder, one located adjoining each end of said cylinder, both being adapted to be actuated by the main piston of the main motor cylinder and each being adapted to control the expansive fluid supply to and exhaust from the main valve fluid actuating chamber adjoining its respective end of such cylinder;

And the provision of means comprising new and useful entities which practically, commercially, efficiently and economically practice to be most advantageous in each of the foregoing, and such other respects which will more clearly appear and be understood by those skilled in this art, from the accompanying drawings and the following description, and the appended claims.

It will be readily appreciated by those skilled in this art, after understanding my invention, that various changes may be made in the means disclosed herein which will produce the same results in substantially the same manner without digressing substantially from my inventive concept or sacrificing any of its outstanding inherent advantages.

With reference to the drawings:

Fig. 1 is a vertical section through the embodiment of my pilot controlled, fluid actuated valve mechanism as applied to the cylinder of a pump motor;

Fig. 2 is a view in plan as taken on the dotted line 2—2 of Fig. 1, the lower half being in plan, the upper left quarter being on a plane at a level with the upper exhaust communication port, and the upper right quarter being on a plane parallel to the upper cylinder communication port;

Fig. 3 is a fragmentary view of the various elements illustrated in Fig. 1, except illustrating the main valve at mid travel position and the main piston near its uppermost end of travel and diagrammatically illustrating the main piston near its bottom end of travel and with the pilot valves in the position they would then occupy;

Fig. 4 is similar to Fig. 3 except illustrating the main valve at full upward travel and the main piston at the top end of its upward stroke about to recede downward in the cylinder, and also diagrammatically illustrating the piston near the downward end of its travel in a position of travel about to actuate the lower pilot valve member;

Fig. 5 is an enlarged fragmentary view of a portion of the elements illustrated in Fig. 1, except that it illustrates the main piston near the downward end of its stroke or travel with the main valve and lower pilot valve at about one-half of their downward travel; and,

Fig. 6 is a side elevation of my valve assembly installed in a pump assembly.

In the drawings, in which the same reference characters indicate the same parts in the several views, Fig. 6 illustrates the pump and motor assembly with the motor cylinder 1 closely coupled to the pump cylinder 2 by an intermediate thimble member 3. The motor piston 4 is connected with the pump piston 5 by the main piston rod 6 and the expansive fluid actuating medium is supplied to and exhausted from the main motor cylinder 1 via the valve chest 7 secured to the cylinder 1 by the stud bolts 8.

The pump motor proper is as follows: A main cylinder body 1 has an internal liner or bushing

insert 1a in which is a cylindrical main bore 1b closed at both ends by the upper and lower main cylinder heads 9 and 9a respectively. Installed in the bore 1b is a slidable and reciprocable main piston 4 with a suitable snap type piston ring 4a. This main piston 4 is coupled to the pump piston 5 by the common piston rod 6 with a packing stuffing box 6a located in the lower cylinder head 9a. The main piston 4 is double acting in the main bore 1b due to the intermittent and alternate admittance and exhaust of the expansive fluid medium to the main bore above and below the piston 4 through the upper and lower cylinder communication ports 10 and 10a respectively. These ports 10 and 10a provide constant communication between the main bore 1b and the bore 1a of the valve chest 1, and are provided with the main piston cushioning ports 10' and 10a' respectively, which in turn maintain constant communication between said ports 10 and 10a and their respective ends of said main bore 1b when the main piston 4 is at or near the ends of its reciprocating travel in such bore.

The valve chest bore 1a lies in a plane parallel to and closely adjoining the main cylinder bore 1b and has suitable upper and lower liners or bushing inserts 1b and 1c respectively. Installed in the liners 1b and 1c is a suitable elongated spool shaped slidable and reciprocable main valve 11. This main valve 11 controls the expansive fluid supply to and exhaust from said main bore 1b via the upper and lower cylinder communication ports 10 and 10a respectively by opening intermittently and alternately to the expansive fluid supply and exhaust ports 1d and 1e. The ports 1d and 1e are located in the periphery of the upper and lower valve chest bore bushing inserts 1b and 1c respectively and coincide with ports 10 and 10a.

The expansive fluid is supplied to the bore 1a of the valve chest 1 from the source of supply via the expansive fluid supply connection 12 secured to the external midsection of the valve chest and thence into the expansive fluid supply chest 12a cored out in the central portion of the valve chest and is in constant communication with the central portion of the valve chest bore 1a.

The exhaust expansive fluid is expended from the valve chest bore 1a to its final destiny via the exhaust communication passageway 13a which is cored in the body of the valve chest 1 and connects both ends of said bore 1a with the exhaust outlet connection 13, which latter is secured to the mid-section of said valve chest body opposite the expansive fluid inlet connection 12.

The main valve 11 is provided with snap type upper and lower rings 11a and 11b respectively mounted in suitable grooves located in the enlarged spool head portions thereof. These rings are machined wider than the ports 1d and 1e in the valve chest bore liners 1b and 1c and are adapted to intermittently and simultaneously pass from one side of the ports to the other during the movement of the valve. The outer ends of the valve chest bore 1a are closed by suitable upper and lower covers 1f and 1g respectively.

These covers 1f and 1g are provided with suitable projections 1h and 1i respectively which each extend inwardly into and centrally of the valve chest bore 1a and have a slidable fit with a plurality of cylindrical recess bores located in the outer ends of the main valve 11. The upper projection 1h has a plurality of diameters 1j and 1k with a cylindro-conical portion 1m interposed therebetween which all fit and correspond to a plurality of diameters 11c and 11d respectively with a conical seat portion 11e interposed therebetween which latter three are located in the upper end of the main valve 11. The lower projection 1i has a similar plurality of diameters 1j' and 1k' with a cylindro-conical portion 1m' interposed therebetween which similarly all fit and correspond to a plurality of diameters 11c' and 11d' respectively, with a conical seat portion 11e' interposed therebetween which latter three are located in the lower end of the main valve 11.

Suitable upper and lower actuating motor cylinders 11f and 11f' respectively for the main valve 11 are provided intermediate the inward ends of the projections 1h and 1i and the inward ends of said recess bores in the ends of said main valve. Suitable upper and lower exhaust cushioning dash pots 11g and 11g' respectively for the main valve 11 are provided intermediate the cylindro-conical portions 1m and 1m' and the larger diameters 1k and 1k' respectively of the projections 1h and 1i.

Suitable elongated, cylindrical, shouldered upper and lower pilot valves 14 and 14a for the main valve 11 are slidably mounted in suitable bushing inserts 14' and 14a' respectively which are pressed into the upper and lower cylinder heads 9 and 9a respectively and which lie in a plane parallel to the main cylinder bore 1b. The inward ends of these pilot valves are smaller than the outer ends thereof and are adapted to project into the bore 1b and to each alternately be contacted by the piston 4 as the piston 4 nears the end of its stroke in the bore. The outward ends of these pilot valves have integral therewith the enlarged head portions 14b and 14b' with frusto-conical shoulders which are adapted to close against corresponding seats 14c and 14c' located in the outer ends of their respective bore liner inserts 14' and 14a'. Outward of the inserts 14' and 14a' in the cylinder heads 9 and 9a respectively are mounted the externally threaded hollow plugs 14d and 14d' which form suitable pressure chambers 12b and 12b' outward from the seats 14c and 14c' respectively. Port communication is established between the expansive fluid supply chest 12a in the central portion of the valve chest and the pressure chambers 12b and 12b' and the expansive fluid may flow from the chest 12a through the ports 12c and 12c' in the chest 1, thence through the ports 12d and 11d' in the upper and lower chest covers 1f and 1g respectively, thence through the ports 12e and 12e' in the upper and lower cylinder heads 9 and 9a, and thence through the ports 12f and 12f' in the inserts 14' and 14a' and into the pressure chambers 12b and 12b' respectively. Inasmuch as the pressure of this supply expansive fluid is always a trifle higher than the maximum pressure within the main cylinder bore 1b, the pilot valves 14 and 14a are retained by this higher pressure in their full inward or normal position of travel, in which they are illustrated in Fig. 1, except when contacted as illustrated in Fig. 5 and upper portion of Fig. 4 by the main piston 4. Port communication is likewise established between the bore of the liner inserts 14' and 14a' and the main valve actuating chambers 11f and 11f' respectively and between said bore of the inserts and the supply expansive fluid pressure chambers 12b and 12b' respectively.

The expansive fluid may flow when pilot valves 14 and 14a are in their normal positions, as illustrated in Fig. 1, from said pressure chambers 12b and 12b' through the grooves 12g and 12g' which

latter are cut through the seats 14c and 14c' at a point coincident with the inward ends of ports 12f and 12f' respectively, thence through the annular shaped chambers 12h and 12h' which are always in constant communication with chambers 12b and 12b' respectively which are formed between the inner bores of the inserts 14' and 14a' and reduced portions of the pilot valves 14 and 14a at a point adjoining the inward ends of the pilot valve heads 14b and 14b' of the latter respectively, thence through the radial ports 12i and 12i' in the inserts 14' and 14a' respectively, thence through the ports 12j and 12j' located in the upper and lower main cylinder heads 9 and 9a respectively, and thence through the ports 12k and 12k' located in the valve chest covers 7f and 7g and extending through the projections 7h and 7i of the latter and into the upper and lower main valve actuating chambers 11f and 11f' respectively. This supply communication between the pressure chambers 12b and 12b' and the main valve upper and lower actuating chambers 11f and 11f' respectively is cut off or terminated and exhaust communication established between the actuating chambers 11f and 11f' and the exhaust passageway 13a when the pilot valves 14 and 14a are actuated by being contacted by the main piston 4 and moved outward beyond about one-third of their full outward travel similar to any one of the positions in which they are illustrated in Fig. 5 and upper portions of Figs. 3 and 4.

When the pilot valves are in these positions of outward travel, the expended expansive fluid may flow from the actuating chambers 11f and 11f' through the actuating chamber communication ports 12k and 12k', thence through the continuation communication ports 12j and 12j', thence through a further continuation of the communication ports terminating in the radial ports 12i and 12i' all respectively, thence through the annular shaped exhaust chambers 13b and 13b'. These chambers 13b and 13b' are always in constant communication with the exhaust passageway 13a. These chambers are formed between the inner bores of the inserts 14' and 14a' and reduced portions of the pilot valves 14 and 14a respectively. These reduced portions are located at a point on the valves intermediate their center non-reduced portions 14e and 14e' and their inward end non-reduced portions 14f and 14f' respectively. The fluid thence flows through the exhaust ports 13c and 13c' extending radially through the inserts 14' and 14a'. The fluid continues from the chambers 13b and 13b' through openings 13c and 13c' through the exhaust ports 13d and 13d' located in the main cylinder heads 9 and 9a, thence through the exhaust ports 13e and 13e' located in the valve chest covers 7f and 7g all respectively, and into the exhaust communication passageway 13a.

Suitable flange joint connections are made between the inward flange faces of the upper and lower valve chest covers 7f and 7g and the upper and lower end faces respectively of the valve chest 7, and also between the side faces of the upper and lower valve chest covers 7f and 7g and the side faces of the upper and lower main cylinder heads 9 and 9a respectively. These covers are secured to the valve chest by the stud-bolts 8a, and are secured to the cylinder heads by the stud-bolts 8b, thus establishing enclosed or pipeless port communication systems extending through the covers and heads for the supply and exhaust of the actuating expansive fluid to and from the main valve actuating chambers 11f and 11f' via the control pilot valves 14 and 14a respectively. They also provide for passage of the supply expansive fluid from the supply chest 12a to the pressure chambers 12b and 12b' adjoining the outer ends of the control pilot valves 14 and 14a respectively.

Starting with the moving elements of the motor in the position in which they are illustrated in Fig. 1, the operation of the motor is as follows: The space beneath the main piston 4 within the main bore 1b is in open communication with the expansive fluid supply chest 12a, and the supply expansive fluid flows from the chest 12a through the radial ports 7e, into the lower cylinder communication port 10a, and thence into the space in said main bore beneath said main piston 4. Simultaneously with the expansive fluid supply entering the space beneath the piston, the space above the piston within the main bore 1b is in open communication with the expansive fluid exhaust communication passageway 13a and the expended expansive fluid above the main piston is free to flow therefrom through the upper cylinder communication port 10 and the ports 7d into the exhaust communication passageway 13a. The main valve control pilot valves 14 and 14a in the meantime are retained in their inward, normal positions of travel in which they are in contact with the seats 14c and 14c' respectively by the higher pressure of the expansive fluid in chambers 12b and 12b' over that in the main cylinder bore 1b.

This admittance of supply expansive fluid beneath the main piston and simultaneous exhaust of the expended expansive fluid above the main piston causes the piston to travel upward from the position in which it is illustrated in Fig. 1 to the position in which it is illustrated in full lines in Fig. 3, and thence on to the position in which it is illustrated in full lines in Fig. 4. As the main piston 4 is thus forced upward in the bore 1b from the Fig. 1 to its position Fig. 4, the upper side of the piston contacts the inward end of the upper pilot valve 14 and forces the pilot valve upward from the position in which it is illustrated in Fig. 1 to the position in which it is illustrated in full lines in Fig. 3, and thence on to the position in which it is illustrated in full lines in Fig. 4. This upward movement of the upper pilot valve 14 causes the non-reduced center portion 14e thereof to first pass over and to thus close off port 12i, thus closing off supply communication between chamber 12b and the main valve upper actuating chamber 11f, and then continue on upward beyond the port 12i to thus open exhaust communication between the actuating chamber 11f and the upper end of the exhaust communication passageway 13a and thereby release the expended expansive fluid in the actuating chamber and allow it to flow therefrom to the passageway 13a. This releasing of the expansive fluid from the actuating chamber 11f to the exhaust makes it possible for the live or supply actuating fluid in the main valve lower actuating chamber 11f' at this time formed inward of the small diameter 7j' in the small bore 11c' to overpower the lower pressure in said upper actuating chamber 11f at this time formed inward of the relatively large diameter 7k in the similar size bore 11d, and thus force the main valve 11 from the position in which it is illustrated in Fig. 1 to the position in which it is illustrated in Fig. 3, thence to the position in which it is illustrated in Fig. 4.

As said main valve 11 is thus forced upward

and arrives at the position in which it is illustrated in Fig. 3, the lower snap ring 11b in the main valve covers the ports 7a and cuts off or terminates the supply of expansive fluid from the supply chamber 12a to the space in the main bore 1b beneath the main piston 4. Simultaneously the upper snap ring 11a in the main valve covers the ports 7d and thus terminates the expended expansive fluid release or exhaust from the space in the main bore 1b above the main piston to the exhaust communication passageway 13a. As the main valve 11 continues its upward travel from the position in which it is illustrated in Fig. 3 to the position in which it is illustrated in Fig. 4, the lower snap ring 11b passes upward beyond the ports 7e and opens communication between the space in the main bore 1b beneath the main piston 4 and the lower end of the exhaust communication passageway 13a to thereby release the expended expansive fluid beneath the main piston and allow it to flow freely therefrom through the lower cylinder communication port 10a and the ports 7e into the lower end of the exhaust passageway 13a.

Simultaneously with the foregoing release of the expended expansive fluid from beneath the main piston and during such continued upward travel of the main valve, the upper snap ring 11a passes upward beyond the ports 7d and opens communication between the expansive fluid supply chest 12a and the space in the main bore 1b above the main piston 4 to admit live or supply expansive fluid from the chest 12a via the ports 7d and 10 into the space above the main piston. Simultaneously during this continued upward travel of the main valve 11 from the position in Fig. 3 to the position in Fig. 4, and approximately simultaneously as the inward end of the small diameter 7j' clears the outward end of the small bore 11c', thus temporarily increasing the size of the lower actuating chamber 11f', the small diameter 7j enters the outward end of the small bore 11c and thus temporarily decreases the size of the upper actuating chamber 11f and also forms an annular shaped cushioning dash-pot external to said small diameter 7j and internal to the relatively large bore 11d. The exhaust expansive fluid thus trapped in this annular shaped cushioning dash-pot is finally compressed into the relatively small annular shaped dash-pot compression space 11g as the cylindro-conical portion 7m of the projection 7h is finally contacted by the seat 11e of the main valve, thus cushioning the main valve as it nears the upward end of its travel, and eventually terminating the upward travel as the portion 7m is contacted.

All communication ports and chambers through which the exhaust expansive fluid passes on being released from either of the actuating chambers 11f and 11f' are made of sufficient size so that the main piston 4 would ordinarily be caused to short stroke due to the main valve 11 reversing the actuating fluid supply and exhaust too rapidly. This feature furnishes a means whereby the exhaust expansive fluid from the actuating chambers may be throttled preferably at some point beyond the pilot valves 14 and 14a, and makes it possible to slow up the motion of the main valve and lengthen the stroke of the piston, or vice versa. Exhaust cushioning control valves 13f and 13f' are installed in the upper and lower valve chest covers 7f and 7g respectively in such a manner so that the size of the exhaust ports 13e and 13e' can be individually, externally and manually regulated so as to adjust the stroke of the main piston during the period it is in operation.

As the main piston 4 is forced downward due to the space above said piston being supplied with expansive fluid and the space beneath the piston being open to the exhaust from the position in which it is illustrated in full lines in Fig. 4 to the position it is illustrated in dotted lines in this figure, thence to the position it is illustrated in in Fig. 5, and finally to its full downward travel position as illustrated in dotted lines in Fig. 1, the upper main valve pilot control valve 14 follows the piston downward in the early part of its travel until it is again in its normal position in contact with its shoulder seat 14c. This closes off the exhaust communication existing between the upper actuating chamber 11f and the upper end of the exhaust passageway 13a via the pilot valve 14, and reestablishes expansive fluid supply communication between the supply chamber 12a and the upper actuating chamber 11f via the pilot valve 14.

As the main piston continues its downward stroke and nears the bottom end of its travel, it strikes or contacts the inward end of the lower pilot valve 14a and causes it to be forced outward from the position it is illustrated in in Fig. 4 to the position in which it is illustrated in Fig. 5, and thence to the position it is illustrated in the dotted lines Fig. 1, whereby the non-reduced central position 14e' of the pilot valve 14a first passes over port 12i' and cuts off or terminates the expansive fluid supply communication existing between the supply chest 12a and the lower actuating chamber 11f' via the pilot valve 14a. It then continues its travel outward beyond the port 12i', uncovers this port and establishes exhaust communication between the lower actuating chamber 11f' and the lower end of the exhaust passageway 13a and allows the exhaust fluid from the actuating chamber to flow freely, unless throttled by the lower exhaust control valve 13f', Fig. 6, therefrom into the exhaust passageway 13a.

This release of the expansive fluid from the relatively large lower actuating chamber 11f to the exhaust makes it possible for the supply pressure of the expansive fluid in the temporarily small upper actuating chamber 11f to over-power the lower pressure of the exhausting expansive fluid in the temporarily large lower actuating chamber 11f and force the main valve 11 downward from the position of travel in which it is illustrated in Fig. 4 to the position of travel it is illustrated in in Fig. 5, and thence to position Fig. 1, during such downward travel of the main valve 11. The upper snap ring 11a is thereby moved from above to directly over and thence below the upper port 7d, which is in constant communication with the space in the main bore 1b above the main piston 4, and thus first cuts off or terminates the existing expansive fluid supply from the supply chest 12a to the bore 1b and then opens or establishes exhaust communication between the port 7d and the exhaust communication passageway 13a, thus releasing the expansive fluid above the piston 4 to the exhaust.

Simultaneously during this downward travel of the main valve 11, the lower snap ring 11b thereof is thereby moved from above to directly over lower port 7e, as illustrated in Fig. 5, and thence below the lower port 7e which is in con-

stant communication with the space in the main bore 1b beneath the main piston 4, and thus first cuts off or terminates the existing exhaust of the expended expansive fluid from the bore 1b to the exhaust communication passageway 13a and then opens or establishes communication between the port 7e and the expansive fluid supply chest 12a, thus admitting live expansive fluid beneath the main piston 4, thereby first cushioning it, and then causing it to reverse its downward motion and start its upward stroke. This completes one complete double stroke cycle of operations. During this downward stroke of the main valve 11, the small diameter bore 11c' of the main valve passes downward over the small diameter 7j' and cuts off communication between dash-pot chamber 11g' and port 12k' in 7i, thus making it necessary for the main valve 11 to compress the remaining exhaust expansive fluid in 11g', Fig. 5, into the space 11g', Fig. 1, and thus cushion the valve before it contacts disc 7m'.

The outer ends or heads of the pilot valves 14 and 14a are machined conical so as to prevent these valves from forming a large contact with the inner sides of the hollow plugs 14d and 14d' respectively, to form a seal therebetween that would cause one or the other, especially the lower, of these valves to fail to return to its normal position of travel wherein it is in contact with its shoulder seat. The main valve 11 is supported solely on the projections 7h and 7i and does not touch the liner inserts of the valve chamber bore. The snap rings 11a and 11b of the main valve are the valve port control means and they alone contact the inner walls of the inserts. These snap rings 11a and 11b of the main valve 11 are made sufficiently wide to slightly overlap the ports 7d and 7e respectively, as illustrated in part in Fig. 5, so as to produce both a slight supply and exhaust lap. The main piston stroke control needle valves 13f and 13f' are threaded into the upper and lower valve chest covers 7f and 7g respectively and control the size of the actuating chambers 11f and 11f' exhaust ports 13e and 13e' respectively. These needle valves may be manually operated by the hand wheels 13i and are locked in position by the jam nuts 13h. The only moving element of this motor that is externally exposed is the piston rod.

Assuming that the main piston 4 and upper and lower pilot valves 14 and 14a respectively are in the position in which they are illustrated in Fig. 1, and that the main valve 11 is in the position in which it is illustrated in Fig. 4, then the main valve 11 would be sustained in the position last mentioned against gravity and the pressure acting in the temporary relatively small diameter upper actuating motor cylinder 11f by the pressure acting in the temporary relatively large diameter lower actuating motor cylinder 11f' against the lower portion of valve 11.

With reference to Figs. 1 and 5, the exhaust cushion compression space 11g', Fig. 1, should be of such volumetric capacity that the exhaust expansive fluid trapped in the space 11g', Fig. 5, could not be compressed in the former mentioned space during the full downward travel of the main valve 11 to a pressure equal to that of the actuating expansive fluid within chamber 11f moving such valve 11 downward.

It is obviously understood that this motor could be used on other appliances than a pump assembly.

The invention described herein may be manufactured and/or used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

Having thus set forth and disclosed the nature of the invention, what is claimed is:

1. In a motor for a pump having a cylinder containing a reciprocable piston member actuated within the cylinder by expansive fluid, a valve chest extending parallel to and secured to the cylinder, said chest having a cylindrically shaped bore, a main valve member slidably mounted in said bore of said valve chest to control the supply and exhaust of the expansive fluid to actuate the piston in the cylinder, said main valve member having a pair of cylindrically shaped recesses, one in each outer end thereof, said recesses forming the actuating motor cylinders therefor, each of said recesses having two diametrical sizes, a pair of covers, one for each end of said valve chest bore, and an inwardly extending projection on each cover having a slidable fit to the two sizes of its mate recess in the end of said main valve member, said projections providing the sole supporting means for said main valve member centrally within the bore of said valve chest.

2. In a motor for a pump having a cylinder containing a reciprocable piston member actuated within the cylinder by expansive fluid, a valve chest extending parallel to and secured to the cylinder, said chest having a cylindrically shaped bore, a main valve member slidably mounted in said bore of said valve chest to control the supply and exhaust of the expansive fluid to actuate the piston in the cylinder, said main valve member having a pair of cylindrically shaped recesses, one in each outer end thereof, said recesses forming the actuating motor cylinders therefor, each of said recesses having two diametrical sizes, a frusto-conical shoulder seat interposed between two diametrical sizes, a pair of covers, one for each end of said valve chest bore, an inwardly extending projection on each cover having a slidable fit to the two sizes of its mate recess in the end of said main valve member, said projections providing the sole supporting means for said main valve member centrally within the bore of said valve chest, and a cylindro-conical shoulder intermediate the two sizes of each projection, each of said shoulders being adapted to contact with and form a seal with its mate seat shoulder in its mate recess in said main valve chamber.

3. In a motor for a pump having a cylinder containing a reciprocable piston member actuated within the cylinder by expansive fluid, a valve chest extending parallel to and secured to the cylinder, said chest having a cylindrically shaped bore, a main valve member slidably mounted in said bore of said valve chest to control the supply and exhaust of the expansive fluid to actuate the piston in the cylinder, said main valve member having a pair of cylindrically shaped recesses, one in each outer end thereof, said recesses forming the actuating motor cylinders therefor, each of said recesses having two diametrical sizes, a frusto-conical shoulder seat interposed between the two diametrical sizes, a pair of covers, one for each end of said valve chest bore, an inwardly extending projection on each cover having a slidable fit to the two sizes of its mate recess in the end of said main valve chamber, said projections providing the sole supporting means for said main valve member centrally within the bore

of said valve chest, a cylindro-conical shoulder intermediate the two sizes of each projection, each of said shoulders being adapted to contact with and form a seal with its mate seat shoulder in its mate recess in said main valve chamber, and an annular shaped chamber adjoining the larger end of each of said disc shoulders wherein expansive fluid can be compressed to form dash-pot cushioning means for said main valve chamber.

4. In a motor for a pump having a cylinder containing a reciprocable piston member actuated within the cylinder by expansive fluid, a valve chest extending parallel to and secured to the cylinder, said chest having a cylindrically shaped bore, a main valve member slidably mounted in said bore of said valve chest to control the supply and exhaust of the expansive fluid to actuate the piston in the cylinder, said main valve member having a pair of cylindrically shaped recesses, one in each outer end thereof, said recesses forming the actuating motor cylinders therefor, each of said recesses having two diametrical sizes, a frusto-conical shoulder seat interposed between the two diametrical sizes, a pair of covers, one for each end of said valve chest bore, an inwardly extending projection on each cover having a slidable fit to the two sizes of its mate recess in the end of said main valve member, said projections providing the sole supporting means for said main valve member centrally within the bore of said valve chest, a cylindro-conical shoulder intermediate the two sizes of each projection, each of said shoulders being adapted to contact with and form a seal with its mate seat shoulder in its mate recess in said main valve chamber, an annular shaped chamber adjoining the larger end of each of said disc shoulders wherein expansive fluid can be compressed to form dash-pot cushioning means for said main valve chamber, and port communication means extending through said inwardly extending projections through which to supply and exhaust the expansive fluid actuating medium to and from said recesses.

5. In a motor for a pump having a cylinder containing a reciprocable piston member actuated within the cylinder by expansive fluid, a valve chest extending parallel to and secured to the cylinder, said chest having a cylindrically shaped bore, a main valve member slidably mounted in said bore of said valve chest to control the supply and exhaust of the expansive fluid to actuate the piston in the cylinder, said main valve member having a pair of cylindrically shaped recesses, one in each outer end thereof, said recesses forming the actuating motor cylinders therefor, each of said recesses having two diametrical sizes, a frusto-conical shoulder seat interposed between the two diametrical sizes, a pair of covers, one for each end of said valve chest bore, an inwardly extending projection on each cover having a slidable fit to the two sizes of its mate recess in the end of said main valve chamber, said projections providing the sole supporting means for said main valve member centrally within the bore of said valve chest, a cylindro-conical shoulder intermediate the two sizes of each projection, each of said shoulders being adapted to contact with and form a seal with its mate seat shoulder in its mate recess in said main valve chamber, an annular shaped chamber adjoining the larger end of each of said disc shoulders wherein expansive fluid can be compressed to form dash-pot cushioning means for said main valve chamber, port communication means extending through said inwardly extending projections through which to supply and exhaust the expansive fluid actuating medium to and from said recesses, and means in the form of a pair of cylindrically shaped pilot valves, one located adjoining each end of said cylinder, and operable by being contacted by said piston to control the expansive fluid supply to and exhaust from said recesses in said main valve member.

6. In a motor for a pump having a cylinder containing a reciprocable piston member actuated within the cylinder by expansive fluid, a valve chest extending parallel to and secured to the cylinder, said chest having a cylindrically shaped bore, a main valve member slidably mounted in said bore of said valve chest to control the supply and exhaust of the expansive fluid to actuate the piston in the cylinder, said main valve member having a pair of cylindrically shaped recessess, one in each outer end thereof, said recesses forming the actuating motor cylinders therefor, each of said recesses having two diametrical sizes, a frusto-conical shoulder seat interposed between the two diametrical sizes, a pair of covers, one for each end of said valve chest bore, an inwardly extending projection on each cover having a slidable fit to the two sizes of its mate recess in the end of said main valve member, said projections providing the sole supporting means for said main valve member centrally within the bore of said valve chest, a cylindro-conical shoulder intermediate the two sizes of each projection, each of said shoulders being adapted to contact with and form a seal with its mate seat shoulder in its mate recess in said main valve chamber, an annular shaped chamber adjoining the larger end of each of said disc shoulders wherein expansive fluid can be compressed to form dash-pot cushioning means for said main valve chamber, port communication means extending through said inwardly extending projections through which to supply and exhaust the expansive fluid actuating medium to and from said recesses, means in the form of a pair of cylindrically shaped pilot valves, one located adjoining each end of said cylinder and operable by being contacted by said piston to control the expansive fluid supply to and exhaust from said recesses in said main valve member, and means external to said valve chest for manually restricting the exhaust fluid outlet from said recesses in said main valve member and for the purpose of manually controlling both the length of stroke of said piston and the cushioning of said main valve member.

7. In a motor for a pump having a cylinder containing a reciprocable piston member actuated within the cylinder by expansive fluid, a valve chest extending parallel to and secured to the cylinder, said chest having a cylindrically shaped bore, a main valve member slidably mounted in said bore of said valve chest to control the supply and exhaust of the expansive fluid to actuate the piston in the cylinder, said main valve member having a pair of cylindrically shaped recesses, one in each outer end thereof, said recesses forming the actuating motor cylinders therefor, each of said recesses having two diametrical sizes, a frusto-conical shoulder seat interposed between the two diametrical sizes, a pair of covers, one for each end of said valve chest bore, an inwardly extending projection on each cover having a slidable fit to the two sizes of its mate recess in the end of said main valve member, said

projections providing the sole supporting means for said main valve member centrally within the bore of said valve chest, a cylindro-conical shoulder intermediate the two sizes of each projection, each of said shoulders being adapted to contact with and form a seal with its mate seat shoulder in its mate recess in said main valve chamber, port communication means extending through said inwardly extending projections through which to supply and exhaust the expansive fluid actuating medium to and from said recesses, means in the form of a pair of cylindrically shaped pilot valves, and one located adjoining each end of said cylinder, operable by being contacted by said piston to control the expansive fluid supply to and exhaust from said recesses in said main valve member.

8. In a motor for a pump having a cylinder containing a reciprocable piston member actuated within the cylinder by expansive fluid, a valve chest extending parallel to and secured to the cylinder, said chest having a cylindrically shaped bore, a main valve member slidably mounted in said bore of said valve chest to control the supply and exhaust of the expansive fluid to actuate the piston in the cylinder, said main valve member having a pair of cylindrically shaped recesses, one in each outer end thereof, said recesses forming the actuating motor cylinders therefor, each of said recesses having two diametrical sizes, a frusto-conical shoulder seat interposed between the two diametrical sizes, a pair of covers, one for each end of said valve chest bore, an inwardly extending projection on each cover having a slidable fit to the two sizes of its mate recess in the end of said main valve member, said projections providing the sole supporting means for said main valve member centrally within the bore of said valve chest, a cylindro-conical shoulder intermediate the two sizes of each projection, each of said shoulders being adapted to contact with and form a seal with its mate seat shoulder in its mate recess in said main valve chamber, port communication means extending through said inwardly extending projections through which to supply and exhaust the expansive fluid actuating medium to and from said recesses, means in the form of a pair of cylindrically shaped pilot valves, one located adjoining each end of said cylinder and operable by being contacted by said piston to control the expansive fluid supply to and exhaust from said recesses in said main valve member, and means external to said valve chest for manually restricting the exhaust fluid outlet from said recesses in said main valve member and for the purpose of manually controlling both the length of stroke of said piston and the cushioning of said main valve member.

FRANK DAVID BUTLER.