May 9, 1933. A. G. GAGE 1,907,951

VALVE MECHANISM FOR FLUID PRESSURE OPERATED WELL PUMPS

Original Filed April 10, 1931 2 Sheets-Sheet 1

Fig. 1

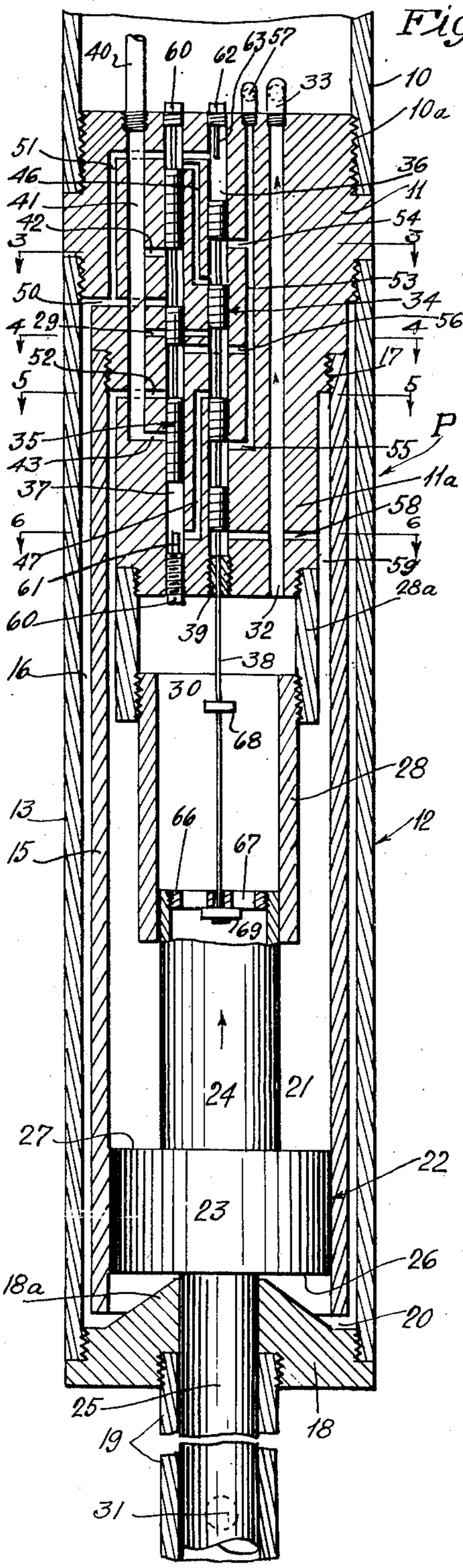

Fig. 2

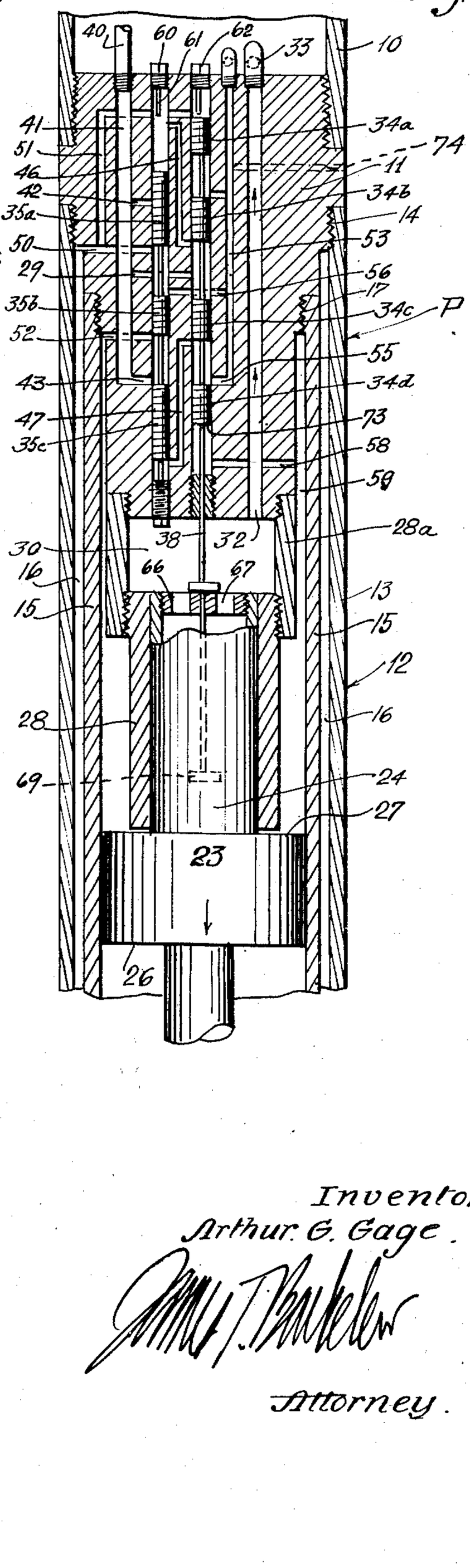

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Fig 3.

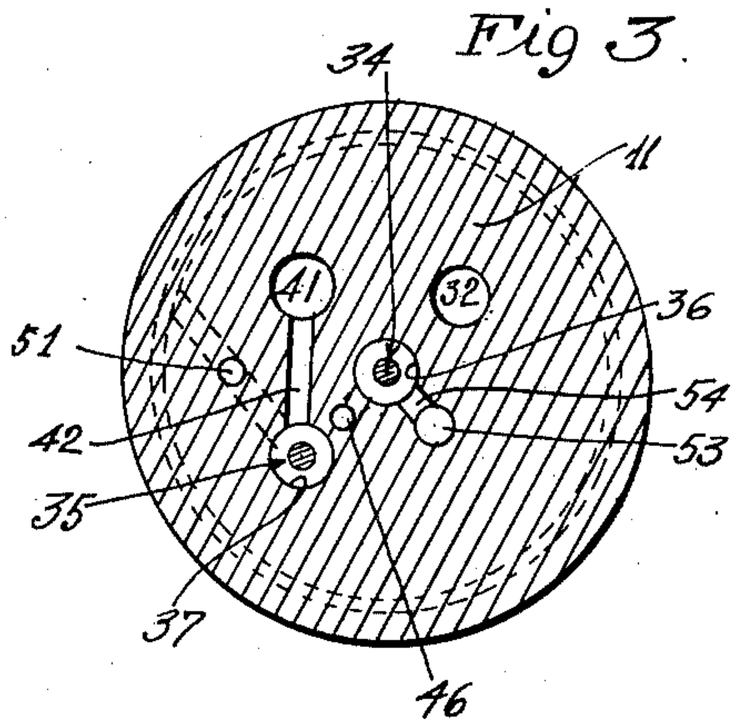


Fig 4.

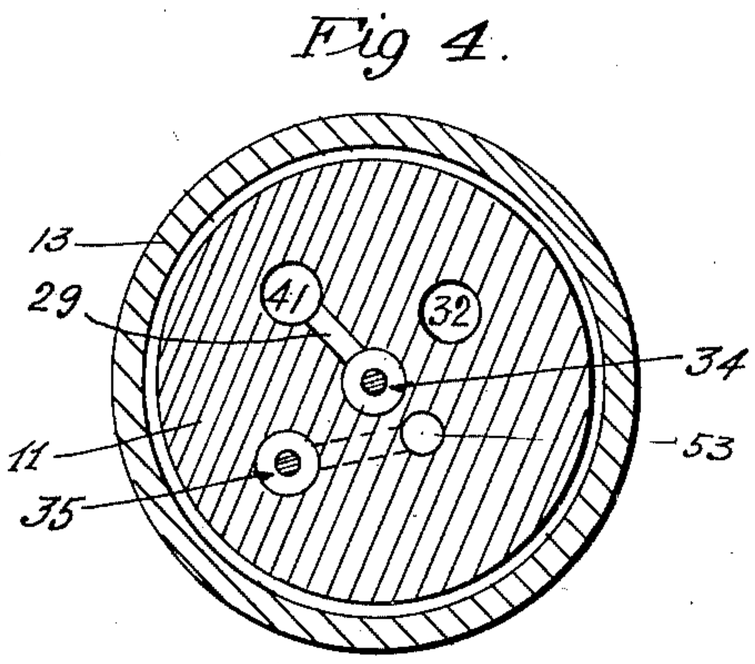


Fig. 5.

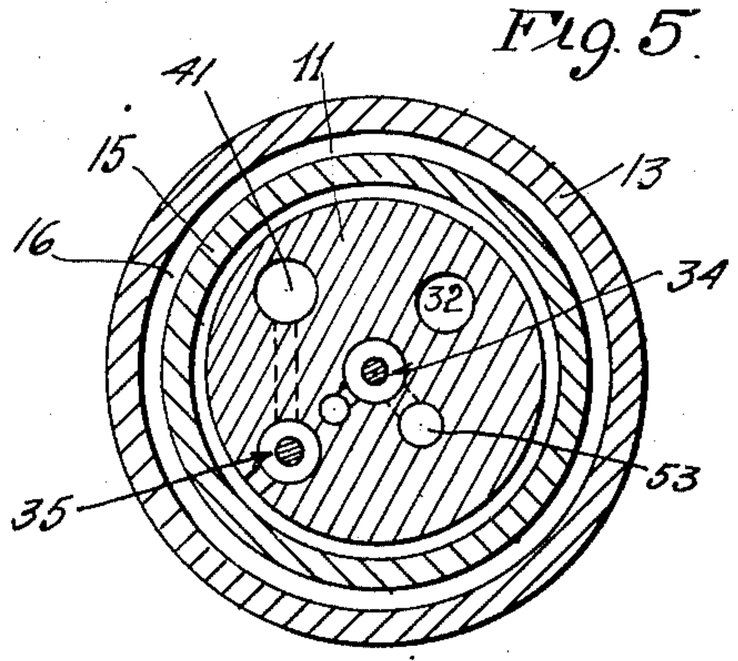
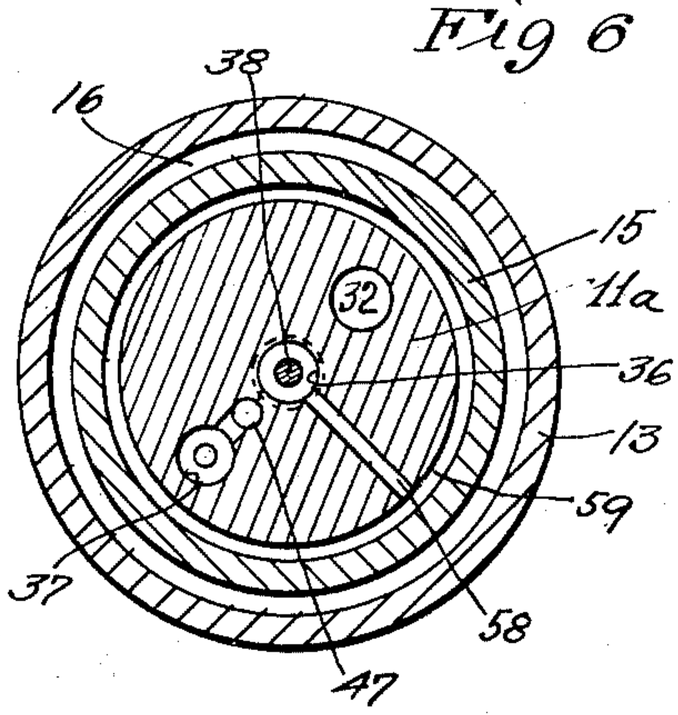


Fig 6



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UNITED STATES PATENT OFFICE

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VALVE MECHANISM FOR FLUID PRESSURE OPERATED WELL PUMPS

Application filed April 10, 1931, Serial No. 529,059. Renewed October 7, 1932.

This invention has to do with deep well fluid pressure operated pumps, and in the majority of its aspects relates to valvular mechanisms in pumps of this type.

Fluid pressure operated pumps of the present type may be characterized as comprising a plunger or piston operated on at least one of its strokes by the high pressure fluid delivered to the pump from the ground level, the well liquid being discharged by the pump upwardly into a standing or pumping column within the well pipe. I may state that pumps typically of this character are described in United States Letters Patent No. 1,597,162 issued on August 24, 1926 jointly to me with L. M. Kellogg and C. H. McWilliams and in my copending application on Oil well pumps, Ser. No. 109,098, filed May 14, 1926. The delivery of high pressure operating fluid to the piston chamber is controlled by a valve or an arrangement of valves which primarily are controlled or operated by the plunger. Thus as the plunger nears the ends of its strokes, it is brought into operating connection with the valve so as to move the latter between two positions of adjustment.

In my copending application on Valve actuating devices, Ser. No. 302,737, filed August 29, 1928, I describe a mechanical locking device for holding the valve in position between the intervals at which it is operated by the plunger. It is primary object of the present invention to obviate the necessity for using a mechanical locking device for so holding the valve in position, by substantially locking the valve against movement between intervals of its operation by the plunger, by means of fluid pressure. It is to be understood that the invention broadly contemplates the use of fluid pressure from any suitable source for locking the valve in position, but in general I prefer to so lock the valve by the application of the plunger operating fluid pressure thereto. In accordance with the hereinafter described preferred embodiment of the invention, the operating fluid pressure is alternately applied to opposing faces on the valve to hold the latter in its two positions of adjustment. The pressure applied to one of the faces not exposed to operating fluid pressure may be either pumping column or well pressure, but in either case the pressure will be substantially less than the operating fluid pressure so as to maintain a sufficient differential between the opposing pressures on the valve to securely hold the latter in position.

In the preferred form of the invention, the valve mechanism comprises a pilot valve operated by the plunger, and a fluid pressure actuated master valve controlled by the pilot valve, both valves being held in position between intervals of operation of the pilot valve by the plunger, by means of differential fluid pressures applied to opposite ends of the valves. Although for purposes of describing the invention I show the valvular mechanism as comprising typically a plunger actuated pilot valve and master valve controlled by the latter, it will be understood that the invention is not to be regarded as necessarily limited to this particular valve construction or arrangement. Also I show herein a type of pump in which the plunger is operated on both of its strokes by successive amounts of high pressure delivered to the pump. Again the invention may not necessarily be limited to a pump in which the plunger is operated in the manner stated. For example it may, instead, be operated on both of its strokes by a single quantity of actuating fluid delivered to the plunger chamber during movement of the plunger in one direction only, as described in a companion application, Ser. No. 529,060 on Fluid pressure operated well pump, filed on even date herewith.

The various objects of the invention as well as the particularities of a typical and preferred embodiment, thereof will be set forth to best advantage and discussed more fully in the following description. In the description I refer to the accompanying drawings, in which:

Fig. 1 is a medial longitudinal and developed sectional view of the pump showing the plunger at the limit of its down stroke,

the various valve parts and passages in the valve head being shown in a single plane for purposes of illustration;

Fig. 2 is a fragmentary view similar to Fig. 1 showing the plunger with the end of its up stroke, and the valve parts in corresponding changed positions; and

Figs. 3, 4, 5 and 6 are sectional views on lines 3—3, 4—4, 5—5, and 6—6 of Fig. 1, illustrating the true relative positions of the valves, and the ports and passages in the valve head.

In Figs. 1 and 2 of the drawings, the pump, generally indicated at P, is carried on the lower end of the well pipe 10, the latter being lowered within the well casing, not shown, and the pump during operation being submerged beneath the standing level of the liquid in the well. The pump comprises an upper valve head 11 threaded on the well pipe at 10*a*, and a lower plunger and plunger barrel assembly section generally indicated at 12. The barrel assembly comprises an outer pipe or casing 13 joined to the valve head at 14, and a piston barrel 15 extending concentrically within the casing 13 and annularly spaced therefrom at 16, the piston barrel being similarly mounted on the valve head at 17. The lower end of the pump casing is closed by a tubular plug 18, carrying a depending sleeve 19 within which the lower reduced section of the plunger operates, as will presently appear. The lower end of the plunger barrel is spaced at 20 from the bottom closure 18 of the casing, in order to provide for communication between the annular space 16 and the piston chamber 21.

Within the barrel assembly is a tubular plunger, generally indicated at 22, and comprising an intermediate piston section 23 and upper and lower reduced diameter extensions 24 and 25, integral therewith, section 25 having a sliding fit within sleeve 19. It will be noted that the upper plunger section 24 is of somewhat greater diameter than section 25, so that there is provided a downwardly facing pressure area 26 on the piston section 23 of greater area than the upwardly facing pressure area 27, reasons for which will hereinafter appear. Plug 18 is formed with a central raised area 18*a* in order to arrest the downward travel of the plunger at a point such that the piston section 23 will not be permitted to cover the annular opening at 20 and thereby cut off communication between space 16 and the piston chamber 21. The plunger section 24 projects upwardly within a pipe sleeve 28 supported from the lower end of the valve head by way of pipe 28*a*. The diameter of sleeve 28 is such that the upper plunger section has a substantially sliding fit therein.

It may be mentioned at this point that during the down stroke of the plunger, on which the latter is moved by fluid pressure applied to the piston area 27, well liquid is taken upwardly through the plunger into the pumping chamber 30 past foot valve 31 carried within the lower tubular plunger section 25. During the upward movement of the plunger, on which the latter is moved by the application of high pressure fluid to the downwardly facing piston area 26, the well liquid taken into the pumping chamber 30 on the down stroke is discharged through the valve head into the well pipe 10, and into what will hereinafter be termed the pumping column.

I may state further with reference to the plunger and plunger barrel assembly, that during its up stroke, substantially the entire upper end area of the plunger, including the area of the piston face 27 and the cross sectional area of the plunger section 24 is exposed to pumping column pressure, since both chamber 21 above the piston and pumping chamber 30 are in communication, through the valve head, with the column of liquid in the well pipe. And during the down stroke of the plunger, the piston area 26 is exposed to pumping column pressure by virtue of the communication of chamber 21 below the piston with the column of liquid in the well pipe, while the interior of the plunger and the pumping chamber 30 are at well pressure, since during the down stroke the well liquid is being taken upwardly through the plunger into said chamber. In order to maintain substantially the same pressure differential between the high pressure operating fluid and the pumping column pressure during both strokes of the plunger, the sections 23, 24 and 25 of the latter will be so proportioned as to cross sectional area that the area of the piston face 26 will be to the cross sectional area of chamber 21 plus the cross sectional area of plunger section 24, as the area of piston face 27 is to the area of face 26.

The construction and arrangement of the plunger and plunger barrel assembly comprises no part of the present invention, since these features of the pump are covered in my copending application, Ser. No. 109,098, referred to hereinabove.

Well liquid in pumping chamber 30 is discharged upwardly into the pumping column by way of bore 32 extending substantially through the valve head 11, there being a check valve 33 at the upper end of bore 32 to prevent return flow into the pumping chamber. The delivery of pressure fluid to the piston chamber, and also the discharge of spent actuating fluid from opposite sides of the piston section of the plunger into the pumping column, is controlled by a valve mechanism comprising a pilot valve 34 and a master valve 35 contained within bores 36 and 37, respectively. The pilot valve com-

prises a plurality of piston sections 34*a*, 34*b*, 34*c*, and 34*d*, interconnected by rod sections of reduced diameter. Depending from the lower piston section 34*d* is a valve operating rod 38 extending downwardly into the pump column chamber 30 through a stuffing box sleeve 39 in the lower end of the valve bore. The master valve 35 also comprises a plurality of piston sections 35*a*, 35*b* and 35*c*, interconnected by reduced diameter rod sections.

High pressure fluid, which may be liquid or gas, but preferably a clean fairly light oil, is delivered to the pump by way of conduit or tube 40 extending downwardly within the well pipe 10 and connecting with the valve head at the upper end of bore 41. The latter is communicable with the master valve bore 37 by way of ports 42 and 43, and with the pilot valve bore 36 by way of port 29. The master valve bore is communicable at its upper and lower ends at points beyond the valve, with the pilot valve bore by way of passage 46 and 47. Master valve bore 37 communicates with space 16 between the pump barrel and the outer casing, by way of a transverse passage 50. A passage 51, leading from bore 50 to the upper end of bore 36 above the pilot valve, serves to put the master valve bore in communication with the pilot valve bore. The master valve bore also communicates with chamber 21 above the piston, by way of a passage 52.

Extending transversely from a longitudinal bore 53 are ports 54, 55 and port 56, opening into the pilot and master valve bores, respectively. At the upper end of bore 53 opening into the pumping column, is a check valve 57. The pilot valve bore has communication with the piston chamber at a point between the lower valve section 34*d* and the stuffing box 39, by way of passage 58 leading to the annular space 59 between the lower reduced diameter section 11*a* of the valve head and plunger barrel 15.

The upper and lower ends of the master valve bore are closed by means of plugs 60, the latter having small extensions 61 which project into the bore a distance sufficient to arrest the travel of the valve at such points that it will not close off the openings of the passages 46 and 47 into the valve bore. The pilot valve bore similarly is closed at its upper end by plug 62 having an extension 63 which is engaged by the valve to prevent closing off the opening of passage 51 into the valve bore.

The pilot valve 34 is intermittently operated by the plunger by way of the depending valve rod 38. A spider 66 having openings 67 to permit the passage of fluid therethrough, is carried in the upper end of plunger section 24, the valve rod 38 extending through a central opening in the spider and carrying a pair of spaced lugs 68 and 69 which are engaged by the spider near the ends of the up and down strokes, respectively, of the plunger.

I shall now describe the operation of the pump assuming first the plunger and valve parts to be in the positions shown in Fig. 1. The high pressure operating fluid delivered to bore 41 through the conduit 40 is conducted through port 42, the master valve bore between valve sections 35*a* and 35*b*, passage 50, and to the lower end of piston chamber 21 beneath the piston section 23, by way of the annular space 16. The pressure so applied to the lower pressure area 27 of the piston causes the plunger to move on its up stroke in the position of the parts shown in Fig. 1. The master valve is held, and substantially locked, in raised position by the differential in operating fluid and pumping column pressure applied to opposite ends of the valve. Operating fluid pressure is applied to the lower end of the valve by way of port 29, the pilot valve bore between valve sections 34*b* and 34*c*, and passage 47. Pumping column pressure is applied to the upper end of the master valve by communication of the valve bore above the valve through passage 46, the pilot valve bore between valve sections 34*a* and 34*b*, port 54 and passage 53. The operating fluid pressure will of course be substantially greater than the pumping column pressure, and the differential therebetween will be sufficient to hold the master valve in raised position. It may be stated at this point that as the master valve is moved from its lower to upper position, fluid in the upper end of the valve bore is displaced to permit upward movement of the valve, into the pumping column by way of passage 46, port 54, and passage 53.

The pilot valve likewise is held and substantially locked in the position shown in Fig. 1 by the differential between the operating fluid and pumping column pressures applied to its opposite ends. Operating fluid pressure is applied to the upper end of the valve by way of port 42, the master valve bore between valve sections 35*a*, 35*b*, port 50, and passage 51. The pressure within the piston chamber above plunger section 23, or in other words, pumping column pressure, is applied to the lower end of pilot valve section 34*d* by way of the annular space 59 and passage 58.

During the up stroke of the plunger, the well liquid previously taken into the pumping chamber 30 during its down stroke, is discharged through bore 32 into the pumping column. Simultaneously, the spent actuating fluid in chamber 21 above the plunger piston section, previously utilized in moving the plunger on its down stroke, is discharged into the pumping column by way

of space 59, port 52, the master valve bore between valve sections 35*b*, 35*c*, port 56, and passage 53.

As the plunger nears the end of its up stroke, spider 66 engages the upper valve rod lug 68, causing the pilot valve to be raised to the position of Fig. 2. The master valve thereupon is thrown down to its lower position by the application of high pressure fluid to its upper end by way of port 29, the pilot valve bore between valve sections 34*b*, 34*c*, and passage 46. Pumping column pressure is applied to the lower end of the master valve by way of bore 53, port 55, the pilot valve bore between valve sections 34*c*, 34*d*, and passage 47. In order to permit downward movement of the master valve, the fluid in the lower end of the bore is discharged through the last mentioned bores and passages, by way of which the lower end of the valve is put in communication with the pumping column pressure.

Upon movement of the master valve to its lower position, high pressure fluid is applied to the upper pressure area 27 of the piston by way of port 43, the master valve bore between valve sections 35*b*, 35*c*, port 52 and space 59. And during downward movement of the plunger by the pressure of operating fluid so applied, the spent fluid in the piston chamber below the piston 23 previously utilized in moving the plunger on its up stroke, is discharged into the pumping column by way of space 16, passage 50, the master valve bore between valve sections 35*a*, 35*b*, port 56 and passage 53. As previously stated, during the down stroke of the plunger, well liquid is taken upwardly therethrough into the pumping chamber past the foot valve 31 carried in the lower end of the plunger.

The pilot valve is also held or locked in its lower position by differential pressure applied to its opposite ends. Thus in Fig. 2, operating fluid pressure is applied to the lower end of valve section 34*d* by way of the piston chamber, annular space 59, and passage 58. The upper end of the pilot valve is exposed to the comparatively smaller pumping column pressure through passage 51 which communicates with the passage through which spent operating fluid is being discharged from the lower portion of the plunger chamber into the pumping column as hereinabove described. The area of the upper end of the pilot valve is of course greater than the bottom pressure area 73 of the lower valve section 34*d*, by the cross sectional area of valve operating rod 38. However, the pressure differential between the operating fluid and pumping column pressure will be sufficient to hold the pilot valve in raised position, in spite of the reduction of pressure area on the lower end of section 34*d* by the valve rod.

The plunger itself of course serves as the primary mover of the valve mechanism. However, it will be apparent that the plunger will continue its movements in the reverse directions until the pilot valve is fully moved from one position to the other, before the application of the fluid pressure to the plunger will be reversed to move it in the opposite direction. And as will be further noted, this reverse of operating well fluid pressure against the plunger cannot occur until the master valve changes position. Therefore the plunger is prevented from stalling on a "dead center" due to the fact that it will continue its movement until the pilot valve is fully moved from one position to the other and to the point at which the master valve, as a result of the application thereto of pressure fluid controlled by the pilot valve, is caused to change position and direct the high pressure fluid to a reverse side of the plunger.

By virtue of the application of differential fluid pressures to opposite ends of the valves, it is assured that during the intervals of engagement of lugs 68 and 69 on the valve operating rod by the plunger, the master valve and pilot valve will be securely held and substantially locked in their respective positions by the application of high pressure fluid. And as previously mentioned, this ability to lock the valves by fluid pressure is of particular advantage in that it eliminates the necessity for use of additional mechanical valve locking devices for holding the pilot valve in position after having been moved by the plunger.

I may, in some instances, particularly where a gaseous high pressure operating fluid is being used, prefer to discharge the spent operating fluid from the plunger chamber to the well instead of the pumping column. In this case, bore 53 may communicate at its upper end with the well through a suitable transverse passage, indicated by the dotted lines 74 in Fig. 2, instead of with the pumping column. As will be apparent, if passage 53 be led to the well instead of the pumping column, the pressure differentials on opposite ends of the master valves will be between the operating fluid pressure and well pressure, instead of the differentials between operating fluid and pumping column pressures. And similarly, the pressure differential applied to opposite ends of the pilot valve when the latter is in its raised position, will also be between the operating fluid pressure and well pressure.

I claim:—

1. A fluid pressure operated well pump adapted to discharge the well liquid upwardly into a pumping column, comprising a plunger barrel, a fluid pressure operated plunger in said barrel, means for moving said plunger in one direction by high pres-

sure fluid, said means including a valve operated by said plunger; to control the application of fluid pressure to the plunger, and means for applying the high pressure fluid pressure and pumping column pressure to opposite ends of said valve to hold the valve in position.

2. A fluid pressure operated well pump adapted to discharge the well liquid upwardly into a pumping column, comprising a plunger barrel, a fluid pressure operated plunger in said barrel, means for moving said plunger in one direction by high pressure fluid, said means including a valve operated by said plunger; to control the application of fluid pressure to the plunger, and means for alternately applying the high pressure fluid pressure and pumping column pressure to opposite ends of said valve to hold the valve in two positions.

3. A fluid pressure operated well pump adapted to discharge the well liquid upwardly into a pumping column, comprising a fluid pressure operated plunger barrel, a plunger n said barrel, means for moving said plunger in one direction by high pressure fluid, said means including a valve operated by said plunger; to control the application of fluid pressure to the plunger, and means for alternately applying differential fluid pressures, to opposite ends of said valve to hold the valve in two positions.

4. A fluid pressure operated well pump adapted to discharge the well liquid upwardly into a pumping column, comprising a plunger barrel, a fluid pressure operated plunger in said barrel, means for moving said plunger in one direction by high pressure fluid, said means including a valve operated by said plunger; to control the application of fluid pressure to the plunger, and means for alternately applying the high pressure fluid pressure to opposite ends of said valve to hold the valve in position.

5. A fluid pressure operated well pump adapted to discharge the well liquid upwardly into a pumping column, comprising a plunger barrel, a fluid pressure operated plunger in said barrel, means for moving said plunger in one direction by high pressure fluid, said means including a valve operated by said plunger; to control the application of fluid pressure to the plunger, and means for applying the high pressure fluid pressure and well pressure to opposite ends of said valve to hold the valve in position.

6. A fluid pressure operated well pump adapted to discharge the well liquid upwardly into a pumping column, comprising a plunger barrel, a fluid pressure operated plunger in said barrel, means for moving said plunger in opposite directions by high pressure fluid, said means including a valve operated by said plunger; to control the application of fluid pressure to the plunger, and means for applying the high pressure fluid and pumping column pressures to opposite ends of said valve to hold the valve in position.

7. A fluid pressure operated well pump adapted to discharge the well liquid upwardly into a pumping column, comprising a plunger barrel, a fluid pressure operated plunger in said barrel, means for moving said plunger in opposite directions by high pressure fluid, said means including a valve for controlling the delivery of high pressure fluid to operate the plunger; and means for alternately applying the high pressure fluid pressure and well pressure to opposite ends of said valve to hold the valve in position.

8. A fluid pressure operated well pump adapted to discharge the well liquid upwardly into a pumping column, comprising a plunger barrel, a fluid pressure operated plunger in said barrel, a valve head above the plunger barrel, means for delivering high pressure operating fluid through said valve head to the plunger barrel to move the plunger in one direction, said means including a vertically movable valve in said head and operated by said plunger, and means for holding said valve in one position by differential fluid pressures applied to opposing faces thereof.

9. A fluid pressure operated well pump adapted to discharge the well liquid upwardly into a pumping column, comprising a plunger barrel, a plunger in said barrel, a valve head above the plunger barrel, means for delivering high pressure operating fluid through said valve head to the plunger barrel to move the piston in opposite directions, said means including a vertically movable valve in said head operated by said plunger to control the flow of fluid through said head; and means for alternately applying differential pressures to opposing faces of said valve to hold the valve in two positions.

10. A fluid pressure operated well pump adapted to discharge the well liquid upwardly into a pumping column, comprising a plunger barrel, a plunger in said barrel, a valve head above the plunger barrel, means for delivering high pressure operating fluid through said valve head to the plunger barrel to move the piston in opposite directions, said means including a vertically movable valve in said head operated by said plunger to control the flow of fluid through said head; and means for applying the high pressure fluid pressure to one end of said valve to hold the valve in position.

11. A fluid pressure operated well pump adapted to discharge the well liquid upwardly into a pumping column, comprising a plunger barrel, a plunger in said barrel, a valve head above the plunger barrel, means for delivering high pressure operating fluid through said valve head to the plunger bar-

rel to move the piston in opposite directions, said means including a vertically movable valve in said head operated by said plunger to control the flow of fluid through said head; and means for alternately applying the high pressure fluid pressure to opposite faces of said valve.

12. A fluid pressure operated well pump adapted to discharge the well liquid upwardly into a pumping column, comprising a plunger barrel, a plunger in said barrel, a valve head above the plunger barrel, means for delivering high pressure operating fluid through said valve head to the plunger barrel to move the piston in opposite directions, said means including a vertically movable valve in said head operated by said plunger to control the flow of fluid through said head; and means for alternately applying the high pressure fluid pressure and pumping column pressure to opposite faces of said valve.

13. A fluid pressure operated well pump adapted to discharge the well liquid upwardly into a pumping column, comprising a plunger barrel, a plunger in said barrel, a valve head above the plunger barrel, means for delivering high pressure operating fluid through said valve head to the plunger barrel to move the piston in opposite directions, said means including a pilot valve in said valve head operated by said plunger and a fluid pressure operated master valve controlled by said pilot valve, said master valve controlling the delivery of operating fluid to the plunger, means for applying fluid pressure to one end of said pilot valve to hold the valve in position, and means for alternately applying differential fluid pressures to the opposite ends of said master valve.

14. A fluid pressure operated well pump adapted to discharge the well liquid upwardly into a pumping column, comprising a plunger barrel, a plunger in said barrel, a valve head above the plunger barrel, means for delivering high pressure operating fluid through said valve head to the plunger barrel to move the piston in opposite directions, said means including a pilot valve in said valve head operated by said plunger and a fluid pressure operated master valve controlled by said pilot valve, said master valve controlling the delivery of operating fluid to the plunger, means for alternately applying high pressure fluid pressure to opposite faces of said pilot valve, and means for alternately applying high pressure fluid pressure to opposite ends of said master valve.

15. A fluid pressure operated well pump adapted to discharge the well liquid upwardly into a pumping column, comprising a plunger barrel, a plunger in said barrel, a valve head above the plunger barrel, means for delivering high pressure operating fluid through said valve head to the plunger barrel to move the piston in one direction, said means including a pilot valve in said valve head operated by said plunger and a fluid pressure operated master valve controlled by said pilot valve, said master valve controlling the delivery of operating fluid to the plunger, means for alternately applying high pressure fluid pressure pumping column to opposite faces of said pilot valve, and means for alternately applying high pressure fluid pressure pumping column to opposite ends of said master valve.

16. In a pump of the character described, the combination of a pump barrel having a medial bore, an upper bore of reduced diameter above said medial bore, and a lower bore of still further reduced diameter below said medial bore, a hollow plunger mounted to reciprocate in the pump barrel, said hollow plunger comprising a piston head adapted to work in said medial bore of the barrel, an upper plunger part of reduced diameter extending upwardly from said piston-head and adapted to work in the said reduced upper bore, whereby an upwardly facing annular area is provided on the upper end of the said piston-head, a lower plunger part of reduced diameter extending downwardly from said piston-head and adapted to work in the said reduced lower bore, whereby a downwardly facing annular area is provided on the lower end of the piston-head of greater extent than the upwardly facing annular area on the upper end of the piston-head, means for admitting fluid under pressure to the medial bore of the barrel above the piston-head, to move the plunger on its down stroke, valve means for intermittently admitting fluid under pressure to the medial bore of the barrel below the piston head to raise the plunger on its up stroke, said valve means comprising a piston operated pilot valve and a fluid pressure operated master valve controlled by said pilot valve, and means for holding said valves in their respective positions by fluid pressure.

17. In a pump of the character described, the combination of a pump barrel having a medial bore, an upper bore of reduced diameter above said medial bore, and a lower bore of still further reduced diameter below said medial bore, a hollow plunger mounted to reciprocate in the pump barrel, said hollow plunger comprising a piston head adapted to work in said medial bore of the barrel, an upper plunger part of reduced diameter extending upwardly from said piston-head and adapted to work in the said reduced upper bore, whereby an upwardly facing annular area is provided on the upper end of the said piston-head, a lower plunger part of reduced diameter extending downwardly from said piston-head and adapted to work in the said reduced lower bore, whereby a

downwardly facing annular area is provided on the lower end of the piston-head of greater extent than the upwardly facing annular area on the upper end of the piston-head, means for admitting fluid under pressure to the medial bore of the barrel above the piston-head, to move the plunger on its down stroke, valve means for intermittently admitting fluid under pressure to the medial bore of the barrel below the piston head to raise the plunger on its up stroke, said valve means comprising a piston operated pilot valve and a fluid pressure operated master valve controlled by said pilot valve, and means for alternately applying the plunger operating fluid pressure to opposite ends of both said pilot and master valves.

In witness that I claim the foregoing I have hereunto subscribed my name this 4th day of September, 1930.

ARTHUR G. GAGE.