May 9, 1933. A. G. GAGE 1,907,950

WELL PUMP VALVE HEAD

Original Filed Aug. 27, 1930 2 Sheets-Sheet 1

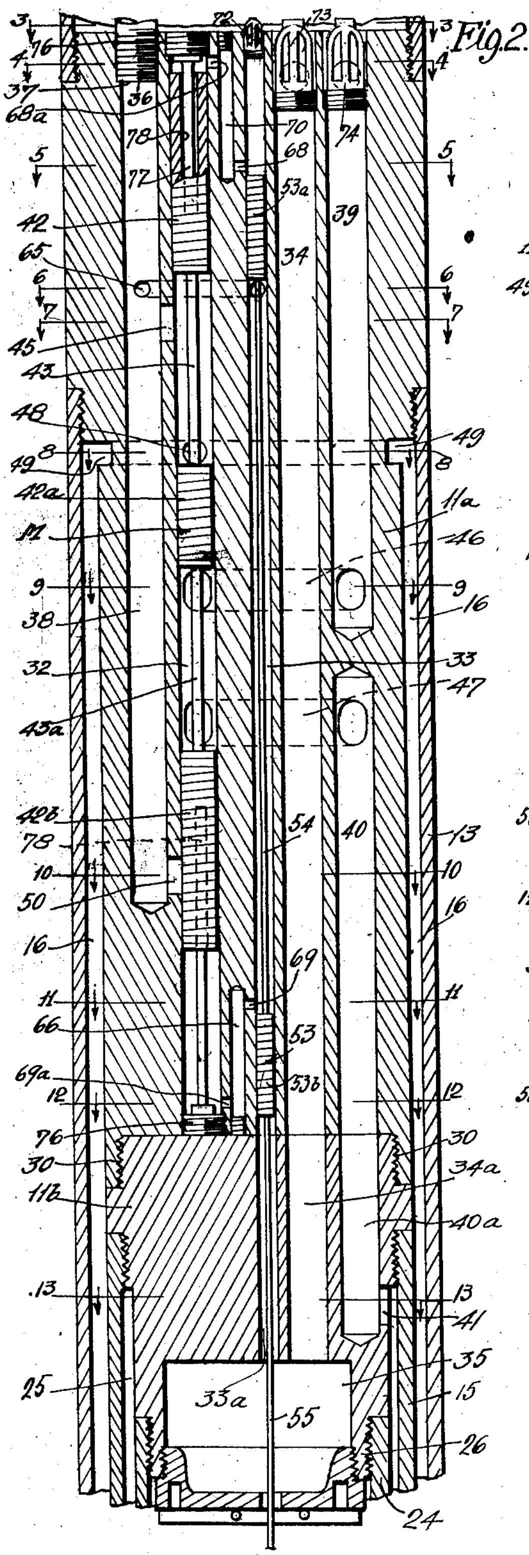


Fig. 2.

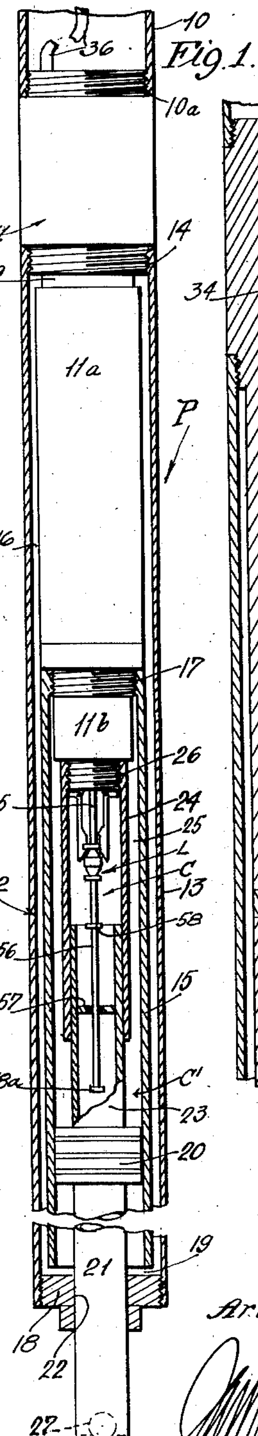


Fig. 1.

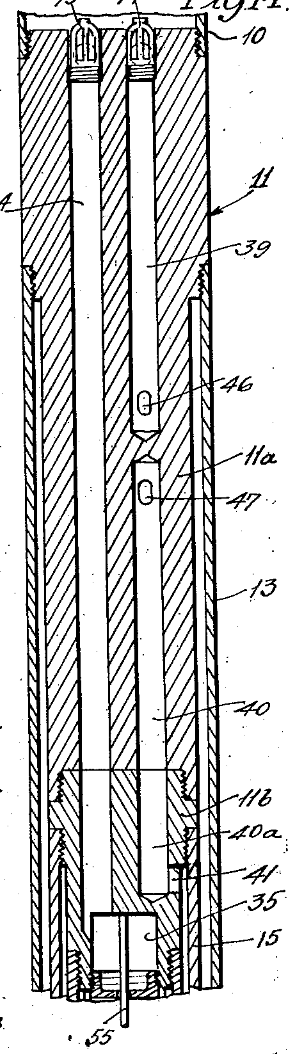


Fig. 14.

Inventor.
Arthur G. Gage.

[signature]

Attorney.

May 9, 1933. A. G. GAGE 1,907,950

WELL PUMP VALVE HEAD

Original Filed Aug. 27, 1930 2 Sheets-Sheet 2

Fig. 3.

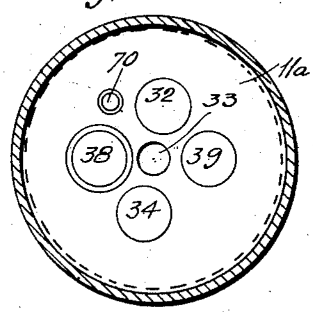


Fig 4

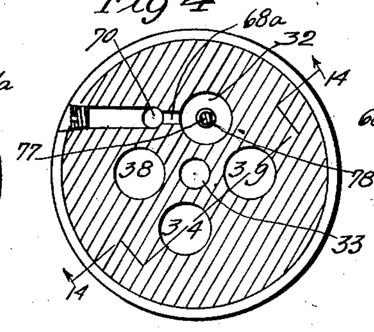


Fig 5

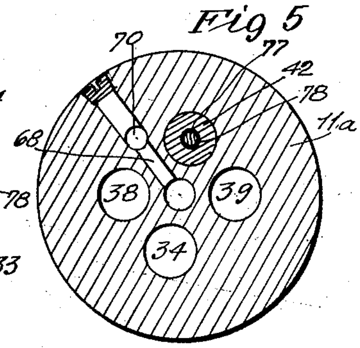


Fig. 6.

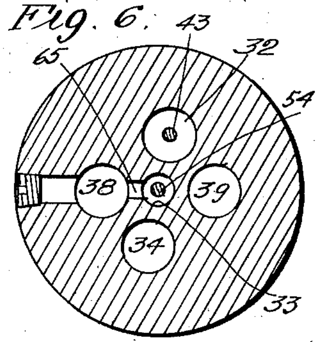


Fig. 7.

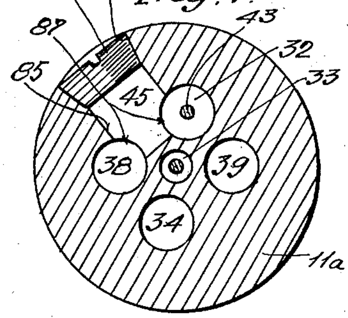


Fig 8.

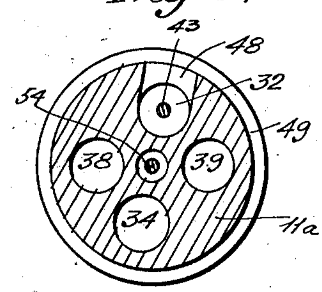


Fig. 9.

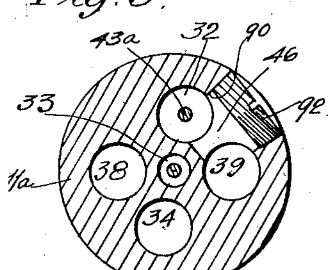


Fig. 10.

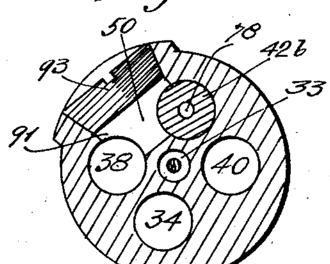


Fig 11.

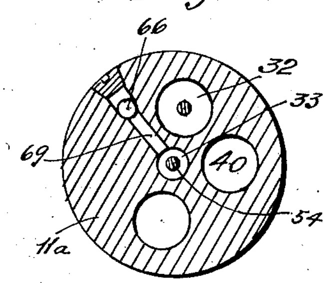


Fig. 12.

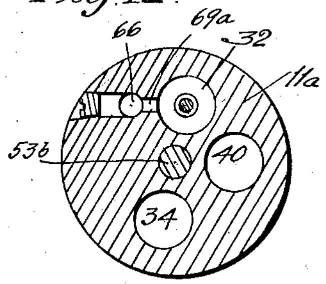
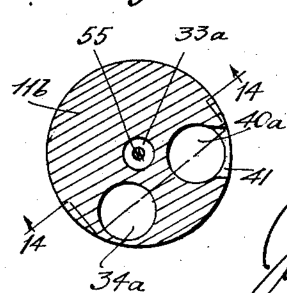


Fig. 13.



Inventor.
Arthur G. Gage.

Attorney.

Patented May 9, 1933 1,907,950

UNITED STATES PATENT OFFICE

ARTHUR G. GAGE, OF LOS ANGELES, CALIFORNIA

WELL PUMP VALVE HEAD

Application filed August 27, 1930, Serial No. 478,161. Renewed October 7, 1932.

This invention has to do with well pumps of the fluid pressure actuated type, and with a form of valve head structure for pumps of this nature whereby the pump may be made in unusually small diameters and thereby enabled to operate in a well bore or pipe or smaller diameter than that heretofore required.

The difficulties encountered in the construction of small diameter pumps of the present type and the manner in which these difficulties are overcome by the invention, may be best explained by first describing generally the pump construction. The pump is adapted to be carried on the lower end of the well pipe through which the pumped liquid is discharged, and comprises a valve head joined to the well pipe, and an assembly of concentric pipe forming the piston and pumping chambers, secured to and depending from the valve head. This concentric pipe assembly comprises three pipes, the outer being secured to the valve head at an upper part of a comparatively large cross section area, an intermediate pipe spaced from the outer pipe and secured to a lower and reduced portion of the valve head, and an inner pipe spaced from the intermediate pipe and joined to the lower and further reduced end of the valve head. Within the intermediate and below the inner pipe is the pump piston which has a reduced extension working within the inner pipe, and into which the well liquid is admitted through the piston. The inner pipe thus serves as a pump chamber and the intermediate pipe as the piston chamber and into which the high pressure fluid is alternately applied to the opposite ends of the piston head by way of the annular spaces between the pipes.

The delivery of high pressure actuating fluid to the piston chamber and the discharge of pumped well liquid and exhaust actuating fluid, occurs through a plurality of bores drilled longitudinally within the valve head, the flow of the actuating and pumping fluids being controlled by reciprocating valves in certain of the valve head bores. The typical form of pump hereinafter described is of the two valve type and comprises a pilot valve operated under the control of the piston, and a master valve operated by fluid pressure controlled in accordance with the movements of the pilot valve. The pilot valve has connection with the piston by way of a rod extending through the pumping chamber, the pilot valve bore therefore extending through the valve head and opening at its lower end into the pumping chamber. The discharge of well liquid from the pumping chamber to the well pipe occurs through a second bore drilled throughout the length of the valve head. Certain other bores are drilled in the upper and comparatively enlarged portion of the head, these bores however terminating short of the lower end of the head. Due to the length of the master valve, its bore must be drilled to a point near the lower end of the head, and since provision must be made at both ends of the master valve bore for conducting the actuating fluid thereto and for cushioning the valve in its movements, the bore is usually drilled continuously through the head into the pumping chamber and plugged at its lower end.

Regardless of the diameter or size of the pump, it is necessary that the valve head bores be of sufficient size to allow unrestricted flow of fluid through the head, and although the pump may be constructed in small diameters, the diameters of the bores may not be decreased below a certain size. When the pump or valve head diameter is reduced to a certain point, the area of the lower reduced end to which the innermost pipe forming the pump chamber is attached, is insufficient to provide stock to permit the master valve and production discharge bores to be drilled straight through the lower end of the head into the pumping chamber. And since it is undesirable to reduce the bore diameter as the pump diameter decreases, the size of the pump is limited to that corresponding to a certain area of the lower reduced end of the valve head which will accommodate the bores drilled through the head, unless means is provided for taking care of the radial offset of the bores from this reduced portion.

It is therefore a general object of my invention to provide a form of valve head construction which will permit the construction of pumps in smaller diameters than would be possible with constructions heretofore used, and in a manner such that the hereinabove mentioned difficulties are entirely overcome. The invention will be most readily and clearly understood from the following detailed description of a typical form of pump constructed in accordance therewith, reference being had throughout the description to the accompanying drawings in which:

Fig. 1 is an elevational view of the pump, certain parts of the piston and pumping barrel assembly being shown in section;

Fig. 2 is an enlarged developed section through the head, the various bores being shown in a single plane for purposes of illustration;

Fig. 3 is a top view of the head on line 3—3 of Fig. 2;

Figs. 4 to 13 are sections taken on lines 4 to 13, respectively, in Fig. 2, illustrating the true positions of the bores in interconnecting ports in the head; and

Fig. 14 is a longitudinal section on lines 14—14 of Figs. 4 and 13.

Referring first to Figs. 1 and 2 of the pump P is shown to be connected at 10*a* with the lower end of the tubing 10, the latter being adapted to be lowered within the well casing (not shown) and the pump during operation being submerged beneath the standing level of the well liquid. The pump comprises the upper valve head section generally indicated at 11 and the lower piston and cylinder assembly section 12. The latter section comprises an outer pipe 13 secured to the valve head at 14, and a piston cylinder 15 extending concentrically within the outer pipe and annularly spaced therefrom at 16, pipe 15 being joined to the valve head at 17. A plug closure 18 is provided for the lower end of pipe 13, the plug being spaced from pipe 15 as at 19. Within cylinder 15 is a piston 20 having a tubular extension 21 depending therefrom through opening 22 in plug 18, pipe 21 carrying the usual foot valve 27 in its lower end.

An inner pipe 24, spaced from intermediate pipe 15 at 25, is joined to the lower end reduced portion 26 of the head. An extension pipe sleeve 23 is carried on the upper end of the piston, the sleeve having a sliding fit within the inner concentric pipe 24. It will suffice to note at this point that the piston is moved on its upward pumping stroke by means of high pressure fluid, preferably a fairly light clean oil, introduced to the piston chamber C′, the interior of pipe 15, by way of spaces 16 and 19, and that the piston is moved downward throughout its return stroke by means of high pressure fluid directed against its upper face by way of space 25. As the piston moves downward, well liquid is permitted to rise through valve 27 into the pumping chamber C within pipes 24 and 23, and during the upward movement of the piston this liquid is discharged through the valve head into the column of liquid, hereinafter termed the pumping column, in well pipe 10. The discharge of pumped liquid through the head as well as the alternate application of high pressure actuating fluid to operate ends of the piston is controlled by the valve mechanism contained within the head 11, which will now be described.

The valve head block is shown to comprise the upper and lower sections 11*a* and 11*b* joined together at 30. The reasons for constructing the valve head in joined sections and the advantages gained by this construction will be best taken up after a description of the arrangement of the various bores and valves contained within the valve head. Master valve bore 32, pilot valve bore 33 and the production discharge bore 34 are drilled throughout the length of valve head section 11*a*, the latter two bores registering with bores 33*a* and 34*a*, respectively, drilled in the lower section 11*b* and opening into a bore 35 drilled in the lower end of section 11*b* somewhat beyond the reduced end portion 26 on which pipe 24 is threaded. The high pressure actuating fluid is delivered to the piston chamber C′ through certain of the valve head bores as will later be described, by way of a conduit 36 extending downward from the ground level through tubing 10, and opening at 37 into bore 38 which terminates short of the lower end of section 11*a*. Bores 39 and 40 are drilled in section 11*a* from opposite ends, bore 40 registering with bore 40*a* in section 11*b* which opens through port 41 to space 27.

A reciprocating master valve M is contained within bore 32, this valve comprising three spaced piston sections 42, 42*a* and 42*b* interconnected by rods 43 and 43*a*. In Fig. 2 the master valve is shown to be in its uppermost position, in which position bore 32 communicates with bore 38 through port 45, and with bores 39 and 40 by way of ports 46 and 47, respectively, these ports opening into bore 32 between the valve piston sections 42*a* and 42*b*. In this position of the valves, bore 32 also is in communication with space

16 between the outer pipes 13 and 15, by way of port 48 leading to the annular channel 49 extending around the head at the upper end of space 16. Thus in the upper position of the valve, high pressure actuating fluid from bore 38 is discharged to space 16 by way of ports 45, bore 32 between the valve sections 42 and 42*a*, and port 48 leading to channel 49; and exhaust liquid in chamber C′ above the piston is delivered through bore 40 to bore 39 by way of ports 47, 46, and bore 32 between valve sections 42*a* and 42*b*.

When the valve is moved to its lower position, not shown, port 45 is closed by the upper piston section 42, bores 38 and 32 communicating through port 50 which is uncovered by the lower valve section 42*b*. The valve section 42*a*, in the lower position of the master valve, is brought between ports 46 and 47 so as to establish communication between space 16 and bore 39 by way of ports 48, 46 and bore 32 between the valve pistons 42 and 42*a*, and to bring bores 38 and 40 into communication by way of ports 47, 50 and bore 32 between valve sections 42*a* and 42*b*. With the master valve in its lower position we have high pressure fluid delivered from bore 38 to chamber C′ above the piston, by way of port 47 and bore 40 as described, and exhaust fluid delivered from chamber C′ below the piston, to bore 39 and thence to the pumping column by way of space 16 and ports 48 and 46.

Within bore 33 is the pilot valve 53 comprising piston sections 53*a* and 53*b* interconnected by rod 54. Rod 55 depends from the valve section 53*b* and is connected to the valve locking device generally indicated at L. Valve actuating rod 56 depends from the lower end of the locking device L and through a spider 57 carried within the piston sleeve 23. Rod 56 carries a pair of spaced lugs 58 and 58*a* which are adapted to be engaged by spider 57 during the reciprocating movement of the piston to actuate rod 56 and to move the pilot valve reciprocally between its upper and lower positions. It will not be attempted to describe the locking device L in detail since this mechanism comprises the subject matter of my copending application on valve actuating device, Ser. No. 302,737, filed August 29, 1928, in which the locking device is explained in detail. For the present purposes it will suffice to state that as the piston approaches the end of its up stroke, at the time the pilot valve and the locking device L are in the positions indicated, spider 57 engages lug 58 so as to raise the valve actuating rod 56, the latter then releasing the locking device so as to permit the pilot valve to move to its upper position in which it again becomes locked by the device L. A reverse procedure follows as the piston approaches the limit of its down stroke, spider 57 engaging lug 58 so as to actuate the locking device and releasing the pilot valve to permit it to return to the original position indicated.

Pilot valve bore 33 between the valve pistons 53*a* and 53*b* is at all times in communication with bore 38 by way of port 65, and when the pilot valve is in its lowermost position, the actuating fluid pressure is applied to the lower end of the master valve by way of ports 65, bore 33 and ports 69, 69*a* and bore 66 leading into the lower end of the master valve bore. Thus in the lower position of the pilot valve, the master valve is held in raised position by the application of the high pressure actuating fluid to its lower end. Upon travel of the pilot valve to its upper position, its pistons 53*a* and 53*b* are moved above ports 68 and 69 respectively, resulting in the delivery of high pressure fluid from the pilot valve bore between the pistons, to the upper end of the master valve by way of ports 68, 68*a* and bore 70. The master valve thereupon is forced downward to its lower position, the fluid contained in bore 32 below piston 42*b* being discharged into the pumping chamber through bore 66. Similarly, as the master valve moves from lower to upper position, the fluid contained above piston 42 is forced out into the pipe 10, or pumping column, through bore 70 and the upper end of the pilot valve bore, a check valve 72 being placed in the end of the bore to prevent return flow. Check valves 73 and 74 likewise are provided at the upper ends of bores 34 and 39 respectively.

In order to prevent the master valve from pounding as a result of the more or less sudden application of high pressure fluid on its ends, means is provided for cushioning the movement of the valve, utilizing the spent actuating fluid at its end. The master valve bore is closed at its ends by means of plugs 76, each having an integral reduced rod extension 77 which projects into bores 78 drilled in the ends of pistons 42 and 42*b*, rods 77 having a suitable clearance from the walls of bores 78. The amount of clearance is such that while the valve is moved away from the end of the valve bore, bore 78 will become substantially filled with liquid, and on the return movement of the valve, the escapement of liquid from bore 78 into the master valve bore will be sufficiently restricted to retard the movement of the valve and prevent it from pounding against the plug. Further details of the valve construction are fully described in a copending application filed on even date herewith, Ser. No. 478,162, entitled Well pump valve.

In the operation of the pump high pressure fluid is delivered to chamber C′ beneath the piston by way of bore 38, the master valve bore between pistons 42 and 42*a*, port 48 and the annular space 16 between the outer pipes of the piston barrel assembly. During the up stroke of the piston, the well liquid previously taken into pipe 23 through the standing valve during its downstroke, is discharged upward through bore 34 and check valve 73 into the pumping column in pipe 10. Spent actuating fluid from chamber C′ above the piston is simultaneously exhausted into the pumping column by way of bores 40, 39, ports 47, 46 and the master valve bore between pistons 42*a* and 42*b*. As the piston nears the limit of its up stroke, the pilot valve is moved to its upper position as previously described, the master valve thrown to its lower position, and the high pressure fluid flow is reversed to the upper side of the piston by way of ports 50 and 47, and bore 40 opening into space 25. During the downward movement of the piston the spent actuating fluid at its under side is exhausted into the pumping column through space 16, ports 48 and 46, and bore 39.

In the drawings I have shown the relative sizes of the valve head and the bores as representative of a pump of small diameter and in which special provision is made to accommodate the required number and arrangement of bores in the valve head. Such provision is necessitated for one reason due to the fact that the area of reduced portion 26 of the head is insufficient to accommodate the master valve, pilot valve and production discharge bores should they be drilled straight through the head, because of their radial offset. Otherwise, assuming the area of portion 26 to be sufficient to accommodate the bores, ample stock would be had to enable the bores to be drilled to the lower end of section 26 without necessitating the drilling of bore 35. Also the master valve bore could be conveniently drilled entirely through the head and plugged at its lower end.

It will be noted upon reference to Fig. 14, in which the true longitudinal positions of bores 34 and 40 are shown, that these bores, if continued straight through the lowermost reduced portion 26 of the head, assuming bore 35 not to be drilled, either would cut through the outside of portion 26, or would barely be contained therein with little stock at the outside of the bores. In other words, the cross sectional area of portion 26 is insufficient to permit either of the radially offset bores 32, 34 or 40 to be drilled entirely through the head and yet leave the desired amount of stock at the outside of the bores. To obviate this difficulty, bore 35 is drilled a sufficient distance beyond the reduced portion 26 to intersect bore 34, which is terminated above the reduced portion.

Master valve bore 32 might likewise be continued through into bore 35, but because of its offset, difficulty would be had in threading the bore at its lower end to accommodate the plug, and also in inserting and seating the plug securely at the required point in the bore. It will be readily apparent also that the drilling of bore 66 from the lower reduced end of the head, and the plugging of bores 39 and 40 at 40*a*, would involve additional difficulties in machining operations.

By drilling bore 34 through the reduced section, and making the diameter of bore 35 preferably as large as the stock at 26 will permit, the necessity is obviated for drilling the production discharge bore straight through the head. In order to obviate the further difficulty in gaining access to the bottom end of the master valve bore to enable the insertion of plug 76 and the valve cushioning rod, and also to facilitate the drilling of bores 66 and 40, I form the head in two sections as illustrated, bores 32 and 38 being drilled only in the upper section 11*a* and bores 33, 34 and 40 being continued into the lower section 11*b*, as previously described. By so forming the head in sections, access is had to the lower end of section 11*a* for the drilling of bores 40 and 66, and for the insertion of plug 76, and to the upper end of section 11*b* for the drilling of bore 40*a* to the point of opening into port 41.

Additional difficulties are encountered due to the necessity for having to drill a plurality of bores in a limited cross sectional area of the head, where it is necessary to drill cross bores between certain of the longitudinal bores and to maintain the cross bores of corresponding diameters. In attempting to drill a cross bore between certain outer pairs of the longitudinal bores, the radial offset of the latter is insufficient to enable a cross bore to be drilled therebetween without intersecting radially inner or centrally located bore. For instance upon inspection of the cross section views in Figs. 4 to 10, it will be seen that the relative positions of the longitudinal bores are such that cross bores of the same diameter should not be drilled between, for instance bores 32 and 38, without intersecting the pilot valve bore 33. Were it not for the necessity for drilling longitudinal bores of large diameters, the relative sizes of the bores might be adjusted so as to prevent intersection of radially inner bore by the cross bore. However, as stated hereinabove, it is necessary, in order to maintain unrestricted fluid flow through the head, that the bores be as large as possible, or at least above a limiting minimum size. The same of course is true with regard to the cross bores.

In accordance with the invention the cross or lateral passages between outer bores are formed other than by cross drilling between and in line with the bores, and by a method such that the lateral passages may clear the centrally located bore. A typical example of this method is shown in the formation of port 45 between bores 32 and 38. A recess 85 is cut radially inward from the side of the head and through the threaded opening 86, to the point of intersection with bores 32 and 38, the width and depth of the recess being such as to form openings at 87 equivalent in size to the areas of the bores. Recess 85 is closed at its outer end by means of plug 88 threaded in opening 86. Thus the fluid is permitted to flow unrestricted from the bore 32 to bore 38 by way of recess 85.

Similar provision is made for forming port 46 between bores 32 and 39, and port 50 between bores 32 and 38, radial recesses 90 and 91 being cut between the respective pairs of bores, and the recesses being closed at their outer ends by plugs 92 and 93.

It will be understood that although for purposes of describing the invention I have shown one particular form of pump which embodies those features with which the invention is concerned, numerous changes in the structure and arrangement of the pump and its parts may be made without departure from the spirit and scope of the invention as set forth in the appended claims.

I claim:

1. In a well pump, a valve head having an upper-portion of relatively large cross sectional area adapted to be joined to the well tubing, and a lower end portion of relatively reduced cross sectional area joined to a pump chamber cylinder, said head having a longitudinal end bore extending upwardly from its lower end to a point above said reduced portion, and a plurality of fluid passage bores drilled longitudinally within the head and radially offset from said end bore, one of said offset bores opening at its lower end into said end bore.

2. In a well pump, a valve head having an upper-portion of relatively large cross sectional area adapted to be joined to the well tubing, and a lower end portion of relatively reduced cross sectional area joined to a pump chamber cylinder, said head having a longitudinal end bore extending upwardly from its lower end to a point above said reduced portion, and a plurality of fluid passage bores drilled longitudinally within the head and radially offset from said end bore, one of said offset bores being drilled part way through the head from the upper end thereof and containing a reciprocating piston valve, and another of said offset bores opening at its lower end into said end bore.

3. In a well pump, a valve head comprising joined upper and lower sections, said upper section having an end portion of relatively larger cross sectional area adapted to be joined to the well pipe, and said lower section having a bottom end portion of relatively reduced cross sectional area joined to a pump chamber cylinder, said head having a longitudinal end bore extending upwardly within its lower section to a point above said reduced portion, and a plurality of fluid passage bores drilled longitudinally within the head and radially offset from said end bore, one of said offset bores opening at its lower end into said end bore.

4. In a well pump, a valve head comprising joined upper and lower sections, said upper section having an end portion of relatively large cross sectional area adapted to be joined to the well pipe, and said lower section having a bottom end portion of relatively reduced cross sectional area joined to a pump chamber cylinder, said head having a longitudinal end bore extending upwardly within its lower section to a point above said reduced portion, and a plurality of fluid passage bores drilled longitudinally within the head and radially offset from said end bore, one of said offset bores extending only through the upper section of the head, and another extending into the lower section and opening into said end bore.

5. In a well pump, a valve head comprising joined upper and lower sections, said upper section having an end portion of relatively large cross sectional area adapted to be joined to the well pipe, and said lower section having a bottom end portion of relatively reduced cross sectional area joined to a pump chamber cylinder, said head having a longitudinal end bore extending upwardly within its lower section to a point above said reduced portion, and a plurality of fluid passage bores drilled longitudinally within the head and radially offset from said end bore, one of said offset bores extending only through the upper section of the head and containing a reciprocating piston valve, means at the ends of the bore for cushioning the movement of the valve, and another of said offset bores extending into the lower section and opening into said end bore.

6. In a well pump, a valve head comprising joined upper and lower sections, said upper section having an end portion of relatively large cross sectional area adapted to be joined to the well pipe, and said lower section having a bottom end portion of relatively reduced cross sectional area, a pump chamber cylinder joined to the reduced end of said lower section, an outer pipe concentrically spaced about said cylinder and joined to the head at a point thereabove, said head having a longitudinal end bore extending upwardly within its lower section to a point above said reduced portion, and a plurality of fluid passage bores drilled longitudinally within the head and radially offset from said

end bore, one of said offset bores extending only through the upper section of the head and containing a reciprocating piston valve, another extending into the lower section and opening into said end bore, and another extending into the lower section and opening to the space between said cylinder and said outer pipe.

In witness that I claim the foregoing I have hereunto subscribed my name this 14th day of August, 1930.

ARTHUR G. GAGE.