April 13, 1954 L. D. HILTON 2,674,955

RECIPROCATING PISTON PUMP WITH VALVED PISTON

Filed April 29, 1949 2 Sheets-Sheet 1

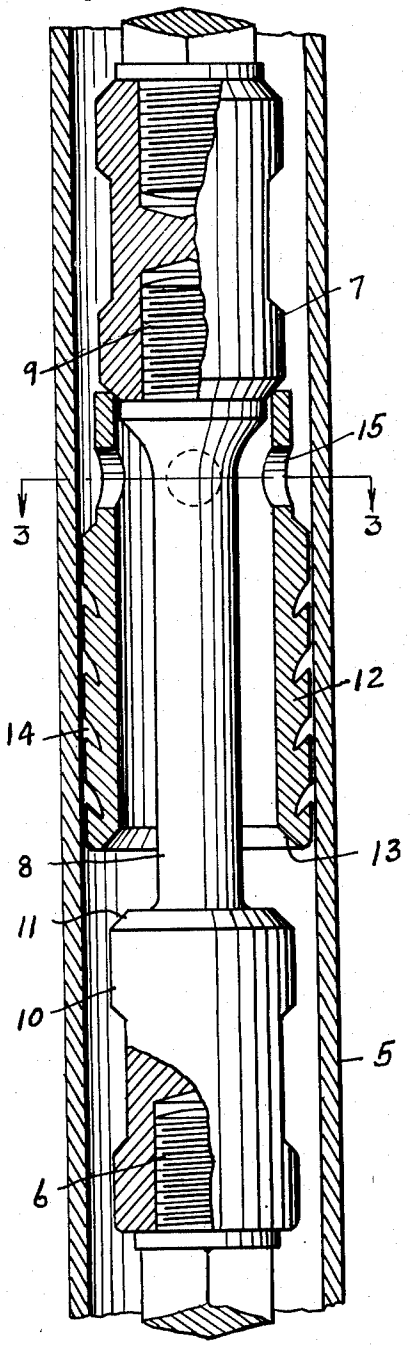


Fig. 1.

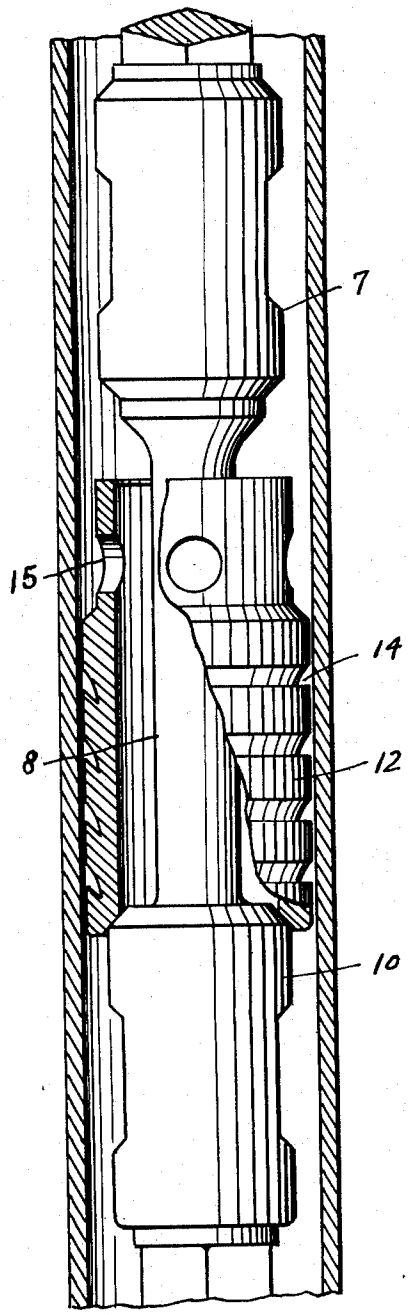


Fig. 2.

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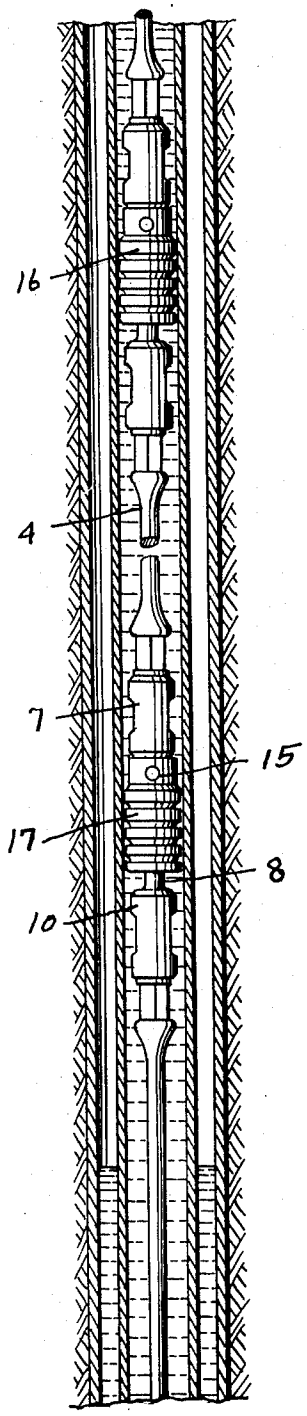
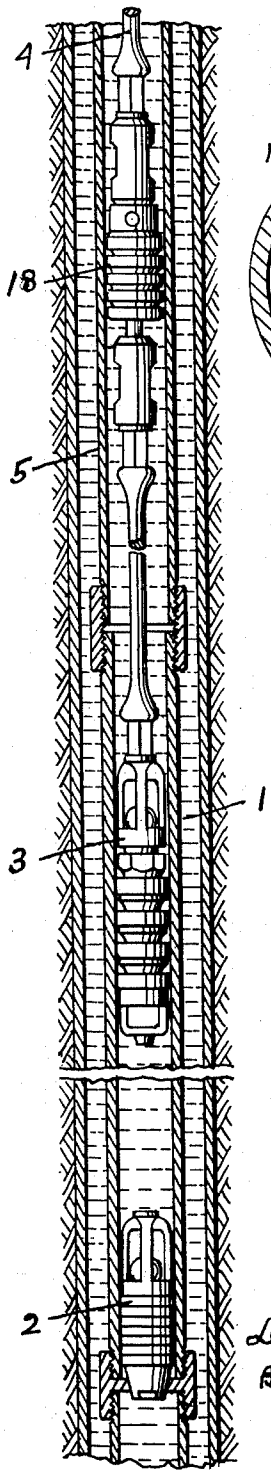


Fig. 4.



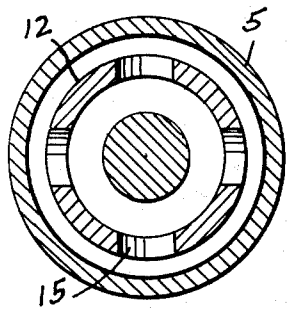


Fig. 3.

Fig. 5.

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UNITED STATES PATENT OFFICE

2,674,955

RECIPROCATING PISTON PUMP WITH VALVED PISTON

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Application April 29, 1949, Serial No. 90,329

3 Claims. (Cl. 103—194)

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This invention relates to pumping equipment for wells and has more particular relation to a pump stager adapted to be mounted on a pump sucker rod.

This equipment includes certain improvements over that type of fluid lift pump rod disclosed in application Serial Number 55,131 filed by this applicant in the United States Patent Office on October 18, 1948.

The invention relates to a conventional fluid lift pump having a working barrel with a standing valve and a travelling valve associated therewith and a sucker rod for reciprocating the travelling valve, the invention relating more particularly to the sucker rod equipped with a single stager or a plurality of stagers spaced a selected distance apart along the sucker rod and of a different design from that disclosed in said co-pending application.

The conditions under which the equipment works are substantially the same as those explained in said co-pending application, and the stager or valve assembly is mounted on the sucker rod in relatively close-fitting relation with the inner bore of the pump tubing so that each stager closes on upstroke of the sucker rod and opens on downstroke, and when installed on the sucker rod at the required point or points distributes the imposed static head along the rod and relieves the travelling valve of that part of the static head load being handled by the stager or stagers above it. For example, with the travelling valve on the lower end of the sucker rod in its operating position in the working barrel and lifting a column of liquid a given height the static head against the travelling valve is a certain pressure per square inch, depending on the static head. With the stager on the sucker rod a given distance above the travelling valve, the static head on the travelling valve will be proportionately reduced and the stager itself will be operating only under the pressure of the column above it. With an additional stager on the sucker rod at a still higher elevation, the static head of the first stager will be therefore reduced, and the second stager will be operating under only the pressure exerted by the column above it. If the travelling valve is worn to reduce its full lifting capacity, and with the first stager installed on the rod above the travelling valve the static head load on the travelling valve will be reduced so that it is readily obvious that the travelling valve need not be removed from the well for repairs until it reaches a point of wear below the capability of raising the fluid

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load to a height at which the stager above picks up the load and stages it up to the next stager above it or to the surface if only one stager is on the rod. It is thus obvious that the pulling expense on oil well pumps will be greatly reduced.

Another object of the present invention is to provide means for retarding the downward drop of the sucker rod and travelling valve after the discharge of the fluid load at the end of the upstroke. The weight of the rod moving downwardly exerts a force that is utilized by the stager to retard the rapid downward plunge of the rod. In other words, the stager forms a choke which retards the flow of fluid through the stager on downstroke and thereby supports the rod. This hydraulic action slows down the rapidly plunging rod and equalizes the travel of the rod with that of the walking beam movement, which eliminates the extremely violent stretching action of the rod at the reversal point at the end of the downstroke. Thus the rod and travelling valve will move more nearly in harmony with the walking beam.

The equipment of the sucker rod with the stagers will conduce to the harmonious movement of the operating equipment at the ground surface and the pumping equipment beneath, thus reducing rod replacements on account of breakage due to metal fatigue occasioned by undue stretching and reducing repairs of surface equipment, which will automatically reduce the pulling expense and maintenance expense as well as power expense and will increase the quantity of fluid raised to the surface within a given time.

A still further object of the invention is to provide equipment of the type described which will conduce to the free flow of gas from the well, thus eliminating gas pockets. It is a further object of the invention to provide equipment of such construction that it will shield the travelling valve from the gritty substances tending to settle out of the liquid being pumped.

Other objects and advantages will be apparent from the following specification, which is illustrated by the accompanying drawings, wherein:

Figure 1 is a fragmentary, side elevation, partly in section, of a stager or lift valve shown in its relation to the pump rod upon the downstroke of the rod.

Figure 2 is a similar view upon the upstroke of the pump rod.

Figure 3 is a cross-sectional view taken on the line 3—3 of Figure 1.

Figure 4 is a sectional view, on a somewhat reduced scale, of a portion of the pump tubing

showing the pump rod therein equipped with pump stagers or lift valves; and

Figure 5 is an extension of Figure 4 showing the pump working barrel connected to the lower end of the tubing with the standing valve and travelling valve therein, the latter being connected to the lower end of the pump rod.

Referring more particularly to the drawings, the numeral 1 designates the pump barrel, mounted in the lower end of which there is the upwardly opening and downwardly closing standing valve 2.

Reciprocable in the barrel above the standing valve there is a conventional travelling valve 3, which opens on downstroke and closes on upstroke and which is connected to the lower end of the pump rod, designated generally by the numeral 4 and also known as the sucker rod.

The pump barrel 1 is connected to the lower end of the well tubing 5, which is of slightly greater inside diameter than the inside diameter of the barrel and which extends to the ground surface.

The travelling valve 3 is reciprocable and is operated by the pump rod. This rod extends to the ground surface and is operated by a walking beam, of conventional construction, or other selected operating equipment.

Upon upstroke of the travelling valve, said travelling valve is closed and elevates the fluid above it and at the same time draws in a charge of well fluid through the standing valve 2.

Upon upstroke of the travelling valve, the standing valve will open to admit said fluid from beneath, and said fluid above the standing valve will pass on up through the travelling valve, upon down stroke of the travelling valve, to be elevated upon the next succeeding upstroke of the travelling valve.

During the operation of the conventional pump the tubing is filled from the pump to the ground surface, and upon each upstroke of the travelling valve, when operated by a pump rod of conventional construction, the entire column of fluid must be lifted, thus imposing on the pump rod not only its own weight but the weight of the column of fluid being pumped as well; and upon downstroke the pump rod moves downwardly very rapidly, that is it substantially drops and is suddenly checked by the reversal of movement of the walking beam from downstroke to upstroke, thus imposing great stresses not only on the pump rod itself but also on the operating equipment. This causes a stretching of the pump rod and also prevents the walking beam or other operating equipment from moving in unison with the travelling valve.

In order to overcome these objections, the pump rod has been equipped with lift valve assemblies, or stagers, spaced apart therealong, whereby the load in the pump tubing will be distributed along the rod upon upstroke of the pump rod, said lift valve assembly, or stagers, being of such construction that they will operate as buffers to retard the downward movement of the pump rod and travelling valve on downstroke.

The upper end of each section of the pump rod is formed with an externally threaded pin 6. If the stager is not employed this pin 6 may be screwed into the lower end of the coupling 7 of the pump rod; however, if a stager is incorporated its lower end is connected to the pin 6, and its upper end is connected to the coupling 7. This stager includes a mandrel 8. The upper end of this mandrel is formed with an outwardly

threaded pin 9 adapted to be screwed into the lower end of the coupling 7, and the lower end of said mandrel is formed with an enlarged coupling member 10, preferably formed integrally therewith, and whose lower end is provided with an internally threaded socket to receive the pin 6. The mandrel 8 is of less transverse diameter than the transverse diameter of the couplings 7 and 10 and the upper end of the coupling 10 is provided with a downwardly and outwardly tapering valve seat 11.

Around the mandrel of each stager there is a sleeve-like valve cage 12 of cylindrical contour and whose lower end is downwardly and outwardly flared, forming a valve 13, which co-operates with the seat 11.

There is only a slight clearance between the valve cage and the inner wall of the pump tubing, and this cage is, preferably, provided with a plurality of external downwardly and inwardly converging grooves 14 forming annular pockets. It will be noted that the over-all length of the valve cage is somewhat less than the distance between the valve seat 11 and the lower end of the coupling 7 above, so that the valve cage and valve may reciprocate relative to the sucker rod, the amount of said reciprocation depending on the length of the mandrel 8 relative to the valve cage.

The upper end of the cage is reduced in external diameter and is provided with the radial openings 15 therethrough of sufficient size to readily permit the outflow of the liquid through said cage upon downstroke of the pump rod.

In the present illustration three stagers are shown and are designated generally by the numerals 16, 17, 18, all of which are similar in construction. However, in practical use these stagers may be distributed along the sucker rod substantially throughout the length thereof at any selected distance apart, and any number of stagers may be used.

During the pumping operation the well tubing 5 will be filled with the liquid being pumped to the ground surface and upon upstroke of the sucker rod the valves 13 will seat in the corresponding valve seats 11 so as to trap the liquid above, but it is observed that each stager will be subjected only to the static head load of liquid between it and the next succeeding stager above to the end that this load elevated by the sucker rod will be distributed along the sucker rod and said entire load will not be concentrated on the travelling valve at the lower end of the sucker rod. The stretch of the sucker rod upon the power stroke will, therefore, be greatly reduced.

On downstroke the valves 13 will be lifted, as shown in Figure 1, so as to permit the liquid beneath to pass upwardly through the corresponding cages 12 and out through the openings 15, the upper ends of said cages, while in this position, being in contact with the lower ends of the corresponding couplings 7; but the downward movement of the sucker rod will be retarded since the upper sides of the openings 15 will act against the liquid passing through said openings as buffers. The openings 15 may be of any selected capacity so as to control the buffing action depending on the length and weight of the sucker rod and so as to have the desired buoyant effect.

Upon upstroke of the sucker rod, the seats 11 will come into contact with the corresponding valves 13 as shown in Figure 2, thus preventing escape of liquid above and the entire column of liquid in the tubing 5 will be lifted, but the stagers being spaced apart the static head load

of the liquid column in the tubing will be distributed along the sucker rod between the plunger itself and the stagers.

As herein above stated there is a slight clearance between the valve cages and the tubing so as to permit lubrication of the cages, but the liquid entering the grooves 14, upon upstroke, will be placed under a condition of ebullition all the way around said cages 12, and this will prevent the passage of any considerable amount of liquid past the stager; in other words, the liquid will act as seal rings and this will also prevent gritty substances from settling out of the fluid being pumped but will keep said substances in suspension in the liquid so that they will be carried up with the liquid rather than settling about the travelling valve.

As is well known, the tubing in a well, particularly a deep one, is not entirely vertical but follows a sinuous course, and it is to be noted that the inside diameter of the valve cages 12 is considerably greater than the transverse diameter of the mandrels 8 so that during the operation of the pump the sucker rod will have considerable free lateral movement as will be required during the reciprocation in a crooked tubing.

The drawings and description disclose what is now considered to be a preferred form of the invention but by way of illustration only and not by way of limitation, while the broad principle of the invention will be defined by the appended claims.

What I claim is:

1. In pumping equipment, a well tubing, a stager including a mandrel adapted to be connected at its upper and lower ends to a pump sucker rod to reciprocate with the rod in the well tubing, said mandrel having a valve seat thereon, a cylindrical-shaped valve cage around the mandrel above the seat and of a greater inside transverse diameter than the transverse diameter of the mandrel, said cage and rod being movable longitudinally relative to each other, the lower end of the cage having an annular valve positioned to seat on said seat on the upstroke of the sucker rod, said cage also having a smaller external diameter than the internal diameter of the well tubing and forming with the tubing a slight annular clearance passageway, said cage also having external annular grooves therearound which converge downwardly and inwardly, and means on the mandrel engageable with the upper end of the cage on the downstroke of said sucker rod to cause the cage to move downwardly with the sucker rod.

2. In pumping equipment, a well tubing, a stager including a mandrel, means connecting the upper and lower ends of the mandrel to the adjacent parts of a sucker rod for reciprocation with the rod in the well tubing, an annular valve seat at the lower end of the mandrel, a cylindrical-shaped valve cage around the mandrel above the seat and spaced radially from said mandrel, said cage being shorter than the distance between the upper one of said connecting means and said seat, a valve on the lower end of the cage positioned to seat on said seat on the upstroke of the sucker rod, the upper end of the cage being of less inside diameter than the external diameter of the upper one of said connecting means and engageable therewith on the downstroke of the rod to cause the cage to move downwardly with the rod, said cage having a smaller external diameter than the internal diameter of the well tubing and forming with the well tubing a slight annular clearance passageway for the passage of fluid between the tubing and cage, said cage also having external annular grooves positioned to receive fluid from said passageway upon downward flow of fluid therethrough to retard the downward flow of fluid through the passageway.

3. In pumping equipment, a well tubing, a stager including a mandrel adapted to be connected at its upper and lower ends to a pump sucker rod to reciprocate with the rod in the well tubing, an annular valve seat at the lower end of the mandrel, a cylindrical-shaped valve cage around the mandrel above the seat and spaced radially from the mandrel, said cage and rod being movable longitudinally relative to each other, said cage having a smaller external diameter than the internal diameter of the well tubing to provide a slight annular clearance passageway between the tubing and cage for the passage of a limited amount of the pumped fluid therebetween, said cage also having external annular grooves therearound which converge downwardly and inwardly in position to receive fluid from said passageway upon upward movement of the cage to resist downward flow of fluid through the passageway, a valve on the lower end of the cage positioned to seat on said seat on the upstroke of the sucker rod, said cage having an upper end portion of reduced external diameter above said grooves and an outlet port through the wall of said portion, and means on the mandrel engageable with the upper end of the cage on the downstroke of the sucker rod to cause the cage to move downwardly with the rod.

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