This invention relates to plunger lift apparatus for raising fluid from a well by means of fluid pressure acting on a plunger which travels the full length of the eduction tubing. This invention is particularly directed to improvements in the construction of the plunger.

One of the difficulties encountered in the operation of plunger lift devices has been the slippage and consequent loss of well fluid between the eduction tubing and the fluid operated plunger. It has been necessary to make the plunger considerably undersized in order that it may travel freely within the tubing, because the tubing is not machined on its inside surface. It is not practicable to employ piston ring type seals for minimizing slippage of well fluid between the plunger and the eduction tubing because such seal rings will not freely pass the joints connecting the individual lengths of eduction tubing.

It is the principal object of this invention to provide a plunger employing a set of compensating shoes which perform the function of an expansion type piston ring and yet which is constructed to pass across recesses at each coupling joint without jamming and without detrimental effects.

A more detailed object of this invention is to provide a plunger body having expansible ring segments actuating to seal against the inside surface of the eduction tubing, the radial position of which segments is regulated by radially movable members extending axially of the plunger body.

Other and more detailed objects and advantages will appear hereinafter.

In the drawings:

Figure 1 is a diagrammatic sectional view of a plunger lift installation and showing a plunger embodying this invention positioned within an eduction tubing.

Figure 2 is a sectional elevation of the upper half of the plunger assembly embodying this invention.

Figure 3 is a sectional view of the lower half of the plunger assembly. The plane of the section of Figure 3 is at 45° from the plane of the section of Figure 2.

Figure 4 is a transverse sectional view taken substantially on the lines 4—4 as shown in Figure 2.

Figure 5 is a perspective view partly broken away showing the assembly of the depression bars and ring segments, the plunger body being omitted for clarity of illustration.

Figure 6 is a perspective view of the plunger assembly.

Figure 7 is a sectional view taken substantially on the line 7—7 as shown in Figure 6.

Referring to the drawings, the swab plunger assembly generally designated 16 is positioned within a sectional eduction tubing 11 which extends into a well bore 12. The bore may be provided with the usual casing 13. Gas under pressure admitted through valve 14 passes downwardly in the annulus 15 between the casing and eduction tubing and acts to cause the well fluid to pass upwardly into the footpiece assembly 10 at the bottom of the well. The well fluid rises in the lower end of the eduction tubing 11. The plunger assembly 10 drops by gravity through the interior of the eduction tubing until it strikes the bumper 17 which is supported on the spring 18. A valve in the plunger assembly classes and gas pressure below the plunger assembly 10 then causes it to move upwardly through the eduction tubing, raising a load of well fluid above it. The well fluid is discharged through ports 19 in the flow nipple 20 and passes outwardly through a restriction valve 21. The reduction in pressure beneath the plunger assembly 10 then allows its valve to open by gravity and the plunger descends by gravity to start a new cycle.

Since the eduction tubing 11 may be several thousand feet in length it is composed of individual tubing sections 22 connected by coupling collars 23. The adjacent ends of tubing sections do not necessarily meet in abutting contact, but on the contrary, a gap or recess 24 is ordinarily present within each coupling collar 23. Furthermore, since the interior surface 25 of the individual tubing lengths 22 is not machined, there is unavoidably some variation in diameter of the inside surface of the tubing.

In accordance with this invention, means are provided for sealing the plunger 10 with respect to the eduction tubing 11, which sealing means are capable of accommodating the variations in diameter of the interior of the eduction tubing and which avoid fouling or interference when the plunger assembly passes over a joint between adjacent tubing sections 22.

As shown in the drawings, the plunger assembly 10 includes a body 26 having an end piece 27 secured at its upper end by means of threads 28 and a valve cage 29 secured at its lower end by means of threads 30. A pair of expandable sealing assemblies is provided on the body, and each of these assemblies includes a plurality of rings 31 which are received in a circumferential groove 32 provided on the body 26. This groove intersects a plurality of longitudinal slots
3 which extend axially of the body and receive axially extending deflector bars 34. The ring segments 31 are notched adjacent their ends as shown at 35 and the bars 34 are each provided with a central relief 36 and side notches 31 which interlock with the notches 31 of the ring segments 31. This arrangement is clearly shown in Figure 5. The depths of the notches 35 and of the reliefs 36 are such that when the segments 31 and bars 34 are in fully extended position, as shown in Figure 4, a continuous circle is formed by the outer surfaces of the bars and segments.

Each of the ring segments 31 is provided with a radially extending recess 33 for reception of a compression spring 39. The inner ends of each of the compression springs 39 rest in the circumferential groove 32. The action of these springs is to urge the segments 31 to move radially outwardly. The bars 34 each overlie a joint between adjacent ring sections 31 and serve to limit outward movement of the segments under influence of the compression springs 39. Each of the bars 34 is provided with axially extending lips 40 at its opposed ends, and these lips 40 extend within counterbores 41 provided at the ends of the valve cage 28 and end piece 27. The bars 34 are free to move radially within the longitudinal slots 33 and to tilt within the slots, but the extent that such movement is limited by engagement of the lips 40 within the counterbores 41. It will be observed that each of the bars 34 is bowed on its outer surface so that the contour is straight for a portion of the bar length and then tapers off on both ends toward the plungers. This feature is so arranged that when the bars are fully depressed into the slots 33, the maximum projection of the bars beyond the outside diameter of the end piece 27 and valve cage 29 is reduced to a minimum. When the bars are fully extended as shown in Figures 2 and 3, their outer surfaces adjacent the extreme ends lie flush with the outside diameter of the end piece 27 and valve cage 29.

The cage 23 is provided with a tapered seat 42, and a valve member 43 moves axially to engage the seat. The valve stem 44 is guided for movement by means of the bushing 45 which is threadedly connected to the lower end of the cage 23. A circular magnet 46 of the type shown and described in the co pending application of Donald G. Knox, Serial No. 767,401, filed August 9, 1947, may be mounted within the cage 23 and held in place against a shoulder 47 by means of bushing 45 and resilient washer 48. The function of this magnet is to assist in maintaining the valve 43 in open position as shown by the dotted lines in Figure 3. The valve is maintained in closed position by gas pressure within the eduction tubing below the plunger assembly 10. A choke ring 49 which is of slightly smaller outside diameter than the end piece 27 and valve cage 29 may be mounted on the lower end of the bushing 45 and held in place by means of a suitable snap ring 50.

When two expansible sealing assemblies are used as shown in the drawings, it is desirable that the slots 33 in the upper assembly be positioned out of line with the slots in the other assembly. In the particular construction shown, using four depression bars 34 in each of the assemblies, it is preferable to position the slots 33 in one assembly at an angle of 45° with respect to the slots in the other assembly.

In operation the swab plunger 18 travels vertically within the eduction tubing 11, and the expansible sealing assemblies form a substantially fluid-tight fit within the interior of the tubing sections 22. The depression bars 34 and ring segments 31 move radially to compensate for minor variations in diameter of the inside surface of the tubing sections. When the plunger 10 passes over a joint between adjacent tubing sections the outwardly bowed or convexly curved outer surfaces of the depression bars contact any projecting edges and move the ring segments 31 radially inwardly to prevent interference. The springs 39 are sufficiently strong to maintain the ring segments and depression bars in sealing relationship with the eduction tubing, but permit contraction of the sealing assemblies in tight spots in the tubing without creating undue friction. The possibility of "hanging up" at joints between adjacent tubing sections is eliminated.

Actual field use has demonstrated that the slippage of well fluid between the plunger 10 and tubing 11 is materially reduced when the plunger incorporates the described embodiment.

Having fully described out invention, it is to be understood that we do not wish to be limited to the details herein set forth, but our invention is of the full scope of the appended claims.

We claim:

1. A fluid operated swab plunger for travel in a sectioned eduction tubing, comprising in combination: a body member, cooperating valve parts on the body member operable to prevent flow of fluid through the plunger, a plurality of longitudinal deflector bars circumferentially spaced around the body member and mounted for radial movement relative to the body member, a segmental ring mounted for radial movement on the body member and positioned between the ends of the deflector bars, resilient means on the body member acting to move the ring segments and longitudinal bars outwardly for sealing contact with the interior of the eduction tubing, the outer surface of each of the deflector bars being curved to cooperate with the ring segments to form a full circle contact with the interior of the eduction tubing.

2. A fluid operated swab plunger for travel in a sectioned eduction tubing, comprising in combination: a tubular body member, a valve on the body member operable to prevent flow of fluid therethrough, a plurality of ring segments mounted for radial movement on the body member, resilient means on the body member acting to move the ring segments outwardly for sealing contact with the interior of the eduction tubing, the outer surface of each of the deflector bars being shaped for contact with the interior of the eduction tubing, the deflector bars being in axial relation to the segmental ring segments, and means on the body member for limiting outward movement of the bars.

3. A fluid operated swab plunger adapted for travel in a sectioned eduction tubing, comprising in combination: a tubular body member provided with axially extending slots and a circumferential groove intersecting the slots, ring segments mounted for radial movement in the groove, resilient means on the body member acting to move the ring segments outwardly for contact with the interior of the eduction tubing.
ing, a plurality of axially extending deflector bars slidably received in the body member slots and each having opposed ends of adjacent ring segments, the outer surface of each of the deflector bars being convexly bowed in an axial direction, a valve on the body member operable to prevent flow of fluid therethrough, and means on the body member adjacent the ends of the bars for limiting outward movement of the bars.

4. A fluid operated swab plunger adapted for travel in a sectional education tubing, comprising in combination: a body member provided with two sets of axially extending slots, the slots in the first set being circumferentially staggered with respect to the second set, the body member having two circumferential grooves, one intersecting each set of slots, ring segments mounted for radial movement in each groove, resilient means on the body member acting to move the ring segments outwardly for contact with the interior of the education tubing, a plurality of axially extending deflector bars received in the body member slots and adapted to limit outward movement of the ring segments, the outer surface of each of the deflector bars being shaped for contact with the interior of the education tubing, cooperating valve parts on the body member operable to prevent flow of fluid therethrough, and means on the body member for limiting outward movement of the bars.

5. A fluid operated swab plunger for travel in a sectional education tubing, comprising in combination: an elongated body member, cooperating valve parts on the body member operable to prevent flow of fluid therethrough, a plurality of axially extending deflector bars circumferentially spaced on the body and each mounted for radial movement relative to the body, the outer surface of each of the deflector bars being transversely curved and being convexly bowed in an axial direction, circumferentially extending ring segment elements operatively associated with the bars intermediate the ends thereof and having outer surfaces forming circumferential continuations of the adjacent portions of the outer surfaces of the bars, and cooperating therewith to form substantially full circle contact with the interior of the education tubing.

6. A fluid operated swab plunger for travel in a sectional education tubing, comprising in combination: an elongated body member, cooperating valve parts on the body member operable to prevent flow of fluid therethrough, a plurality of axially extending deflector bars circumferentially spaced on the body and each mounted for radial movement relative to the body, the outer surface of each of the deflector bars being transversely curved and being convexly bowed in an axial direction, circumferentially extending ring segment elements operatively associated with the bars intermediate the ends thereof and having outer surfaces forming circumferential continuations of the adjacent portions of the outer surfaces of the bars, and cooperating therewith to form substantially full circle contact with the interior of the education tubing.

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