July 27, 1954 D. G. KNOX 2,684,633

EXPANSIBLE PLUNGER FOR PLUNGER LIFTS

Filed March 5, 1951 2 Sheets-Sheet 1

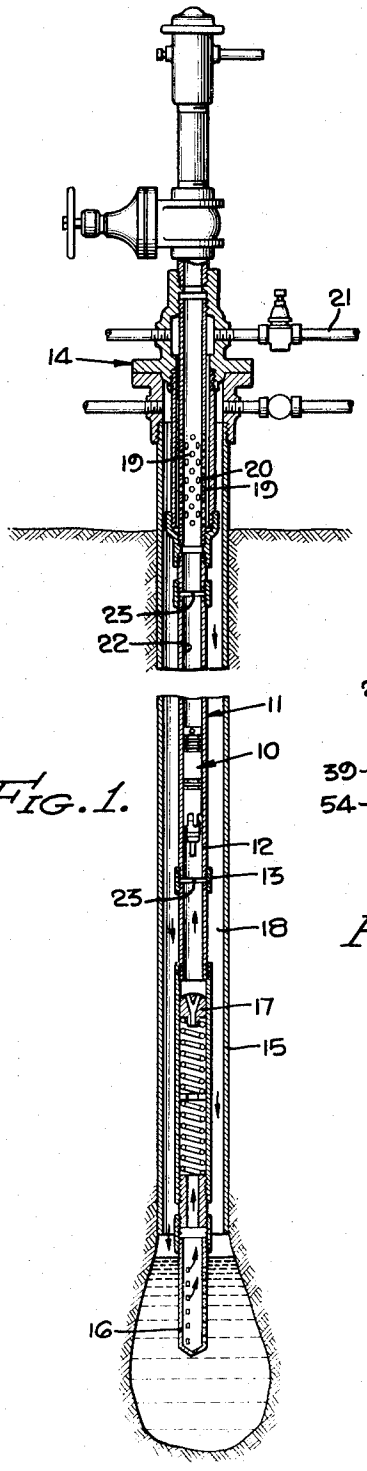


FIG. 1.

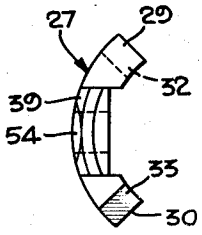


FIG. 7.

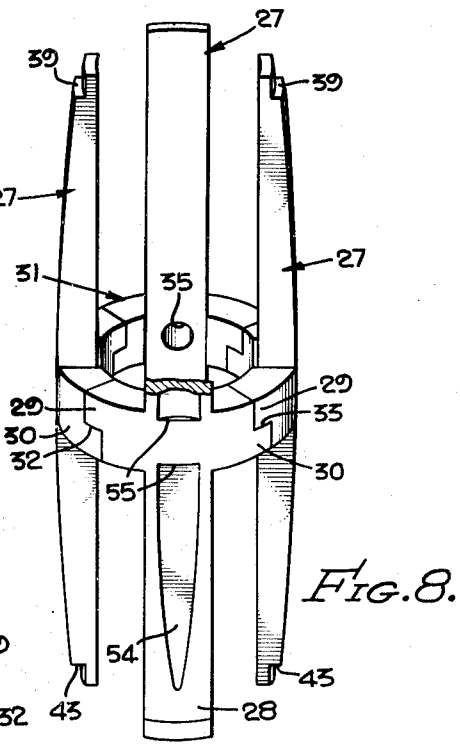


FIG. 8.

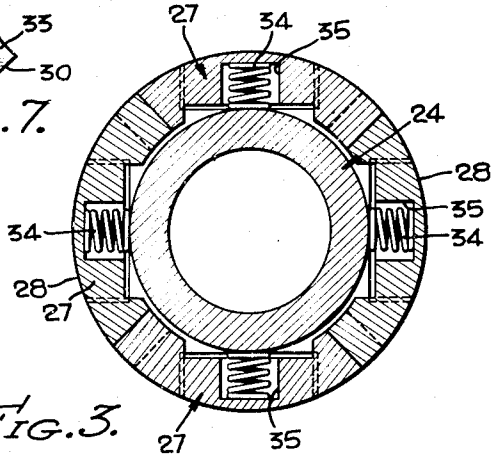


FIG. 3.

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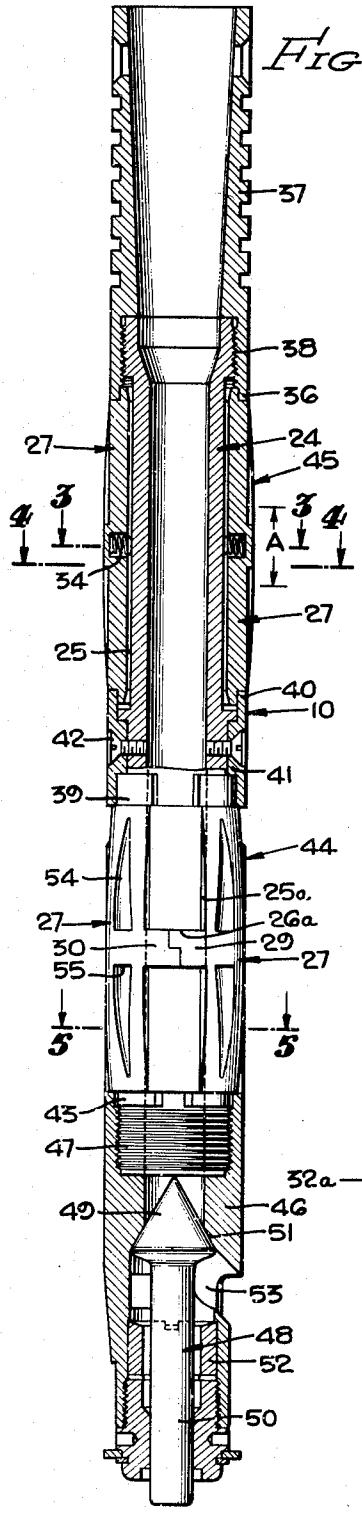
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July 27, 1954 D. G. KNOX 2,684,633

EXPANSIBLE PLUNGER FOR PLUNGER LIFTS

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FIG. 2.



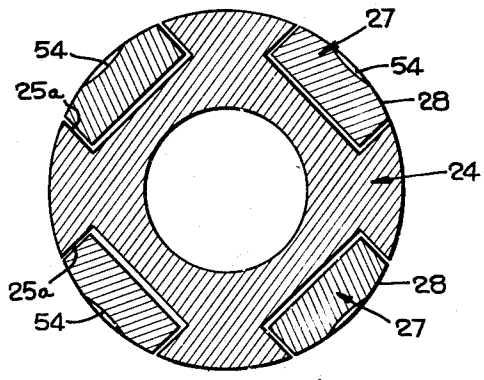


FIG. 5.

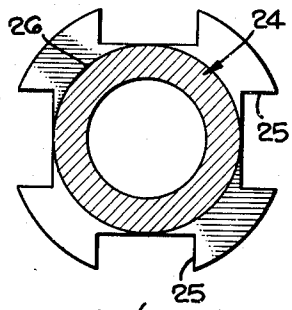


FIG. 4.

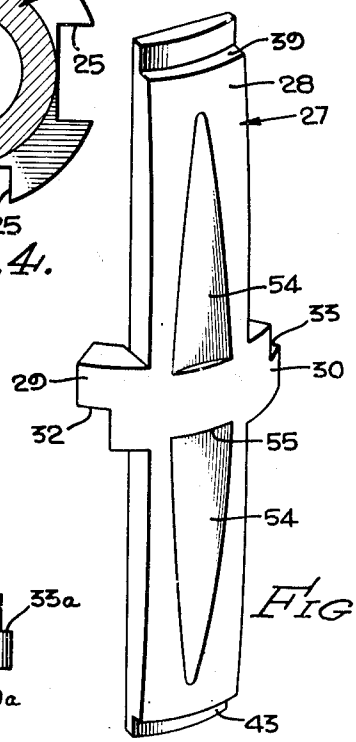


FIG. 6.

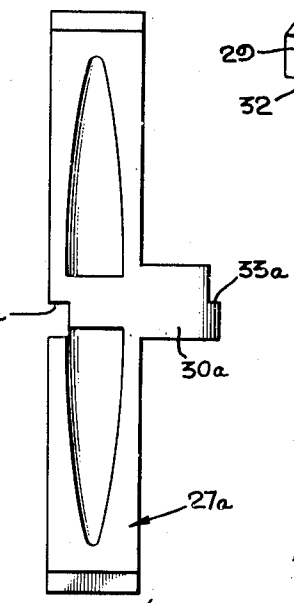


FIG. 9.

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UNITED STATES PATENT OFFICE

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EXPANSIBLE PLUNGER FOR PLUNGER LIFTS

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Application March 5, 1951, Serial No. 213,886

16 Claims. (Cl. 103—52)

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This invention relates to plunger lift apparatus and is particularly directed to improvements over the type of plunger construction shown in the copending application of Donald G. Knox and James W. Lawrence, Jr., for "Plunger Lift Device," Serial No. 83,850, filed March 28, 1949, Patent No. 2,642,002 issued June 16, 1953.

Plunger lift devices are used to raise well fluid through an eduction tubing, and the plunger automatically travels the full length of the eduction tubing. Since the tubing is composed of sections of pipe joined by threaded couplings, the construction of the plunger must be such that it will not foul or "hang up" when passing over a joint between the tubing sections. However, in order to minimize slippage and consequent loss of well fluid, the plunger must maintain a seal with the inside surface of the sectional eduction tubing. The plunger construction disclosed in said copending application meets these requirements satisfactorily, but a relatively large number of close tolerance, high quality, accurate parts are required.

It is an object of the present invention to retain the advantageous features of the plunger construction disclosed in said copending application while reducing the number of parts employed and simplifying the manufacturing procedures and assembly operations.

Another object is to provide a more rugged, trouble-free construction which will serve for long periods of use under operating conditions in the field.

Other and more detailed objects and advantages will appear hereinafter.

In the drawings:

Figure 1 is a diagrammatic illustration, partly in section, showing a plunger lift installation of the type to which the present invention pertains.

Figure 2 is a side elevation, partly in section, showing details of construction of a plunger embodying this invention.

Figure 3 is a sectional plan view taken substantially on the line 3—3 as shown in Figure 2.

Figure 4 is a sectional plan view taken substantially on the line 4—4 as shown in Figure 2, the depression bars and segments being omitted.

Figure 5 is a sectional plan view taken substantially on the line 5—5 as shown in Figure 2.

Figure 6 is a perspective view of one of the depression bars embodying my invention.

Figure 7 is an end view thereof.

Figure 8 is a perspective view partly broken away showing an assembly of the depression bars and integral ring segments, the plunger body being omitted for clarity of illustration.

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Figure 9 is a side elevation showing a modified form of depression bar.

Referring to the drawings, the swab plunger assembly generally designated 10 is positioned within the eduction tubing 11 which extends into the well. The eduction tubing 11 is composed of tubing sections 12 connected at adjacent ends by threaded collars 13. The eduction tubing 11 is suspended from the well head assembly 14 at the surface and extends down through the casing 15. Well fluid passes into the eduction tubing through the perforated liner 16 and through the spring mounted footpiece 17. Gas under pressure within the annulus 18 between the casing 15 and eduction tubing 11 causes the well fluid to rise in the lower end of the eduction tubing 11. The plunger assembly drops by gravity through the eduction tubing 11 until it rests on the spring supported bumper or footpiece 17. A valve in the plunger assembly closes, and gas pressure then causes the plunger assembly to move upwardly through the eduction tubing, raising a load of well fluid above it. The well fluid passes out through discharge ports 19 in the flow nipple 20 and is discharged through outlet pipe 21 at the well head. The valve in the plunger opens mechanically or by gravity because of the reduction in pressure within the eduction tubing, and the plunger assembly drops by gravity to start a new cycle.

During the upward travel of the plunger assembly 10 within the eduction tubing 11, the plunger assembly 10 must fit closely within the inner surface 22 of the eduction tubing 11 to avoid passage of gas under pressure around the outside of the plunger assembly. The plunger construction, however, must be such that there is no possibility of developing interference or hanging up at the gaps or recesses 23 between adjacent ends of tubing sections 12. The sealing means on the plunger must be capable of accommodating the variations in internal diameter of commercially available tubing sections 12. Tolerances on internal diameter of commercial tubing are relatively wide so that the sealing means on the plunger must be capable of radial expansion and contraction.

The plunger assembly 10 comprises a tubular body 24 which is provided with a series of longitudinally extending circumferentially spaced slots 25 in its periphery. Preferably two different series of slots are provided, the lower slots 25a being axially spaced from the upper series and being disposed out of line with the slots in the upper series. In the particular construction illustrated in the drawings, the lower slots 25a

are located at an angle of 45° with respect to the slots in the upper series. A circumferential groove 26 is provided on the tubular body 24 at a location intermediate the ends of the slots 25, and a similar groove 26*a* is provided on the body intermediate the ends of the slots 25*a*. As shown in Figure 4, the bottoms of the slots 25 are flat and are tangent to the bottom of the groove 26.

Axially extending depression bars 27 are slidably mounted for radial movement within the axially extending slots 25. Each of these depression bars 27 is transversely curved on its outer surface 28 to fit within the interior surface 22 of the eduction tubing 11. As shown clearly in Figure 6, integral wings or lugs are provided on each depression bar 27 at a point intermediate the ends thereof. These wings 29 and 30 on each depression bar 27 are formed so that their outer surfaces and the outer surface of the depression bar which lies adjacent to them cooperate to define a portion of a cylinder. The wings 29 and 30 are received within the groove 26 on the body 24. When the depression bars 27 are assembled into operative position the adjacent wings 29 and 30 on adjoining depression bars cooperate to define a ring generally designated 31. This ring is segmental because it is formed by the segments which comprise the cooperating wings 29 and 30.

The wings or lugs 29 and 30 are notched so that they provide a step joint when assembled. Thus, the wing 29 is notched on its lower side to form a recess 32, while the wing or lug 30 is notched on its upper side to provide a similar recess 33. As will be readily understood from a consideration of Figure 8, the notch on one wing or lug receives the projecting portion of the adjacent wing or lug so that the parts interfit to define the segmental ring 31. A coil spring 34 is mounted in each of the recesses 35 provided in the depression bars 27. The springs act under compression to move each of the depression bars 27 radially outwardly from the tubular body 24 so that the wings 29 and 30 and the adjoining portions of the depression bars 27 may seal within the surface 22 on the tubing 11. Means are provided for limiting the outward movement of the depression bars 27, and as shown in the drawings, this means includes a skirt 36 provided on the lower end of the body extension 37 connected to the body by threads 38. The skirt 36 is received within the groove 39 formed at the upper end of each of the depression bars 27. A similar skirt 40 is provided by the sectional retaining ring 41 which is secured to the body 24 by means of suitable threaded fastenings 42. This skirt 40 is received within the grooves 43 provided on the lower end of each of the depression bars 27.

The outer surface 28 of each of the depression bars 27 is transversely curved, and this outer surface is also convexly bowed in an axial direction. I prefer to make the central portion of the depression bars 27 adjacent the wings 29 and 30 straight. The length of this straight section may vary, but a length which gives satisfactory sealing results is shown in Figure 2 and designated A. The remainder of the length of the outer surface of the depression bars tapers inwardly in both directions. If desired, this outer surface 28 of the depression bars 27 may be interrupted by longitudinally extending realtively shallow recesses 54 which terminate in radial shoulders 55. These recesses 54 minimize frictional drag or contact with the eduction tube and the shoulders 55 act as scraping knives to remove the paraffin from the interior surface 22 of the eduction tubing 11.

The lower sealing assembly 44 which operates in the slots 25*a* and groove 26*a* is substantially the same as the upper sealing assembly 45 which operates in the slots 25 and groove 26, and hence need not be further described in detail.

The valve housing 46 comprises an extension on the lower end of the body 24 and is connected thereto by threads 47. A poppet-type valve 48 having a head 49 and stem 50 is mounted for axial movement relative to the housing 46. A seat 51 on the housing 46 is engaged by the valve head 49 to form a seal. A ring magnet 52 may be mounted in the housing 46 for holding the valve in its lower open position, as described in my copending application for "Plunger Construction," Serial No. 767,401, filed August 8, 1947, now Patent No. 2,661,024. When the valve 48 is in its lowest position the side ports 53 in the valve housing 46 establish communication between the interior of the tubular plunger assembly 10 and the interior of the eduction tubing 11 below the plunger assembly.

In the modified form of depression bar 27*a* shown in Figure 9, one of the wings has been lengthened and the other shortened until only one long wing 30*a* is present. A notch 32*a* in one side of the depression bar 27*a* receives the projection on the wing 30*a* of an adjacent depression bar, while the notch 33*a* cooperates with the side surface on an adjacent depression bar. The function of the depression bar 27*a* is substantially the same as that previously described.

In operation, the swab plunger assembly 10 travels vertically within the eduction tubing 11, and the expansible sealing assemblies 44 and 45 form a substantially fluid-tight seal with the inner surface 22 of the eduction tubing 11. The depression bars 27 and wings 29 and 30 move radially to compensate for minor variations in diameter of the surface 22. When the plunger assembly 10 passes over a joint between adjacent tubing sections 12, the outwardly bowed and convexly curved outer surfaces 28 of the depression bars 27 engage any projecting edges on the eduction tubing sections 12 and move the wings 29 and 30 radially inwardly to prevent interference. The compression springs 34 maintain the wings 29 and 30 and the depression bars 27 in sealing relationship with the surface 22 of the eduction tubing 11 but permit contraction of the sealing assemblies 44 and 45 in tight spots in the tubing sections 12 without creating undue frictional resistance.

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

I claim:

1. A fluid operated swab plunger for travel in a sectional eduction 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 depression bars circumferentially spaced on the body, guide means on the body mounting each bar for radial movement relative to the body, the outer surface of each of the bars being transversely curved and being convexly bowed in an axial direction, circumferentially extending ring segment elements fixed on the bars intermediate the ends thereof and having outer surfaces forming circumferential continuations of the adjacent portions of the outer surfaces of the bars, the ring segment elements and bars cooperating to form substantially full

circle contact with the interior of the eduction tubing, resilient means on the body member for moving the bars outwardly, and stop means on the body member for limiting the extent of movement of said bars.

2. A fluid operated swab plunger for travel in a sectional eduction tubing, comprising in combination: a tubular body member, a plurality of axially extending depression bars circumferentially spaced on the body, guide means on the body mounting each bar for radial movement relative to the body, the outer surface of each of the bars being transversely curved and being convexly bowed in an axial direction, circumferentially extending ring segment elements fixed on the bars intermediate the ends thereof and having outer surfaces forming circumferential continuations of the adjacent portions of the outer surfaces of the bars, the ring segment elements and bars cooperating to form substantially full circle contact with the interior of the eduction tubing, a valve on the tubular body member movable between a closed position preventing flow of fluid through the body member and an open position permitting flow therethrough, resilient means on the body member for moving the bars outwardly, and stop means on the body member for limiting the extent of movement of said bars.

3. A fluid operated swab plunger for travel in a sectional eduction 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 depression bars circumferentially spaced on the body, guide means on the body mounting each bar for radial movement relative to the body, the outer surface of each of the bars being transversely curved and being convexly bowed in an axial direction, circumferentially extending ring segment elements fixed on the bars intermediate the ends thereof and having outer surfaces forming circumferential continuations of the adjacent portions of the outer surfaces of the bars, the ring segment elements and bars cooperating to form substantially full circle contact with the interior of the eduction tubing, resilient means on the body member acting to move the bars and ring segments radially outwardly, and means on the body member for limiting the extent of outward movement of the bar.

4. A fluid operated swab plunger for travel in a sectional eduction tubing, comprising in combination: a tubular body member provided with a plurality of axially extending circumferentially spaced slots, cooperating valve parts on the body member operable to prevent flow of fluid therethrough, a plurality of axially extending depression bars, guide means on the body mounting each bar for radial movement in one of said slots, the outer surface of each of the bars being transversely curved and being convexly bowed in an axial direction, circumferentially extending ring segment elements fixed on 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 eduction tubing, resilient means on the body member for moving the bars outwardly, and stop means on the body member for limiting the extent of movement of said bars.

5. A fluid operated swab plunger for travel in a sectional eduction tubing, comprising in combination: a tubular body member provided with a plurality of axially extending circumferentially spaced slots and a circumferential groove intersecting the slots, cooperating valve parts on the body member operable to prevent flow of fluid therethrough, a plurality of axially extending depression bars each mounted for radial movement in one of said slots, the outer surface of each of the bars being transversely curved and being convexly bowed in an axial direction, circumferentially extending ring segment elements fixed on the bars intermediate the ends thereof and received in said groove, said elements having outer surfaces forming circumferential continuations of the adjacent portions of the outer surfaces of the bars, the ring segment elements and bars cooperating to form substantially full circle contact with the interior of the eduction tubing, resilient means on the body member for moving the bars outwardly, and stop means on the body member for limiting the extent of movement of said bars.

6. A fluid operated swab plunger for travel in a sectional eduction tubing, comprising in combination: a tubular body member provided with a plurality of axially extending circumferentially spaced slots and a circumferential groove intersecting the slots, a plurality of axially extending depression bars each mounted for radial movement in one of said slots, the outer surface of each of the bars being transversely curved and being convexly bowed in an axial direction, circumferentially extending ring segment elements fixed on the bars intermediate the ends thereof and received in said groove, said elements having outer surfaces forming circumferential continuations of the adjacent portions of the outer surfaces of the bars, the ring segment elements and bars cooperating to form substantially full circle contact with the interior of the eduction tubing, and a valve on the tubular body member movable between a closed position preventing flow of fluid through the body member and an open position permitting flow therethrough, resilient means on the body member for moving the bars outwardly, and stop means on the body member for limiting the extent of movement of said bars.

7. A fluid operated swab plunger for travel in a sectional eduction tubing, comprising in combination: a tubular body member provided with a plurality of axially extending circumferentially spaced slots and a circumferential groove intersecting the slots, a plurality of axially extending depression bars each mounted for radial movement in one of said slots, the outer surface of each of the bars being transversely curved and being convexly bowed in an axial direction, circumferentially extending ring segment elements fixed on the bars intermediate the ends thereof and received in said groove, said elements having outer surfaces forming circumferential continuations of the adjacent portions of the outer surfaces of the bars, the ring segment elements and bars cooperating to form substantially full circle contact with the interior of the eduction tubing, a valve on the tubular body member movable between a closed position preventing flow of fluid through the body member and an open position permitting flow therethrough, resilient means on the body member acting to move the bars and ring segments radially outwardly, and means on the body member adjacent the ends of the bars for limiting outward movement of the bars.

8. A fluid operated swab plunger for travel in a sectional eduction tubing, comprising in com-

bination: an elongated body member provided with a plurality of axially extending circumferentially spaced slots and a circumferential groove intersecting the slots, cooperating valve parts on the body member operable to prevent flow of fluid therethrough, a plurality of axially extending depression bars each mounted for radial movement in one of said slots, the outer surface of each of the bars being transversely curved and being convexly bowed in an axial direction, circumferentially extending wings fixed on both sides of each of the bars intermediate the ends thereof and having outer surfaces forming circumferential continuations of the adjacent portions of the outer surfaces of the bars, the wings each having stepped ends interfitting the adjacent wings, the wings and bars cooperating to form substantially full circle contact with the interior of the eduction tubing, resilient means on the body member for moving the bars outwardly, and stop means on the body member for limiting the extent of movement of said bars.

9. A fluid operated swab plunger for travel in a sectional eduction tubing, comprising in combination: a tubular body member, a valve on the body member, a plurality of axially extending depression bars each mounted for radial movement on the body, the outer surface of each of the bars being transversely curved and being convexly bowed in an axial direction, circumferentially extending wings fixed on both sides of each of the bars intermediate the ends thereof and having outer surfaces forming circumferential continuations of the adjacent portions of the outer surfaces of the bars, the wings each having stepped ends interfitting with adjacent wings, the wings and bars cooperating to form substantially full circle contact with the interior of the eduction tubing, resilient means on the body member acting to move the bars and wings radially outwardly, and means on the body member adjacent the ends of the bars for limiting outward movement of the bars.

10. A fluid operated swab plunger for travel in a sectional eduction tubing, comprising in combination: a tubular body member, cooperating valve parts on the body member operable to prevent flow of fluid therethrough, a plurality of axially extending depression bars, guide means on the body mounting each bar for radial movement on the body, the outer surface of each of the bars being transversely curved and being convexly bowed in an axial direction, a pair of wings fixed on each bar intermediate the ends thereof and extending circumferentially therefrom in opposite directions, each of the wings having a projection and a recess interfitting with corresponding parts on an adjacent wing, the wings and bars cooperating to form substantially full circle contact with the interior of the eduction tubing, resilient means on the body member for moving the bars outwardly, and stop means on the body member for limiting the extent of movement of said bars.

11. A fluid operated swab plunger for travel in a sectional eduction tubing, comprising in combination: a tubular body member, cooperating valve parts on the body member operable to prevent flow of fluid therethrough, a plurality of axially extending depression bars, guide means on the body mounting each bar for radial movement on the body, the outer surface of each of the bars being transversely curved and being convexly bowed in an axial direction, said outer surface having an axially extending relatively shallow recess therein terminating in a transverse shoulder, circumferentially extending ring segment elements fixed on the bars intermediate the ends thereof and having outer surfaces forming continuations of the adjacent portions of the bars, and cooperating therewith to form substantially full circle contact with the interior of the eduction tubing, resilient means on the body member for moving the bars outwardly, and stop means on the body member for limiting the extent of movement of said bars.

12. A fluid operated swab plunger for travel in a sectional eduction tubing, comprising in combination: an elongated body member provided with a plurality of axially extending circumferentially spaced slots and a circumferential groove intersecting the slots, cooperating valve parts on the body member operable to prevent flow of fluid therethrough, a plurality of axially extending depression bars each mounted for radial movement in one of said slots, the outer surface of each of the bars being transversely curved and being convexly bowed in an axial direction, a ring segment fixed on one side of each bar intermediate the ends thereof and extending circumferentially therefrom in said groove, a projection on the end of each ring segment, each bar having a notch on the other side to receive a similar projection on an adjacent ring segment, the ring segments and bars cooperating to form substantially full circle contact with the interior of the eduction tubing, resilient means on the body member for moving the bars outwardly, and stop means on the body member for limiting the extent of movement of said bars.

13. A fluid operated swab plunger for travel in a sectional eduction tubing, comprising in combination: a tubular body member, cooperating valve parts on the body member operable to prevent flow of fluid therethrough, a plurality of axially extending depression bars, guide means on the body mounting each bar for radial movement on the body, the outer surface of each of the bars being transversely curved and being convexly bowed in an axial direction, a ring segment fixed on one side of each bar intermediate the ends thereof and extending circumferentially therefrom, a projection on the end of each ring segment, each bar having a notch on the other side to receive a similar projection on an adjacent ring segment, the ring segments and bars cooperating to form substantially full circle contact with the interior of the eduction tubing, resilient means on the body member for moving the bars outwardly, and stop means on the body member for limiting the extent of movement of said bars.

14. A fluid operated swab plunger for travel in a sectional eduction tubing, comprising in combination: a tubular body member, a valve on the body member, a plurality of axially extending depression bars, guide means on the body mounting bar for radial movement on the body, the outer surface of each of the bars being transversely curved and being convexly bowed in an axial direction, a ring segment fixed on one side of each bar intermediate the ends thereof and extending circumferentially therefrom, a projection on the end of each ring segment, each bar having a notch on the other side to receive a similar projection on an adjacent ring segment, the ring segments and bars cooperating to form substantially full circle contact with the interior of the eduction tubing, resilient means on the body member acting to move the bars radially outwardly, and

means on the body member adjacent the ends of the bars for limiting outward movement of the bars.

15. A depression bar for a fluid operated swab plunger, comprising: an elongated bar having parallel sides and having an outer surface transversely curved and convexly bowed in an axial direction, a pair of wings fixed on each bar intermediate the ends thereof and extending from opposite sides of the bar, the outer surface of the wings cooperating with the transversely curved surface of the bar to define an arc of a circle, each of the wings having a projection and a recess adapted for interfitting engagement with corresponding parts on duplicate bars.

16. A depression bar for a fluid operated swab plunger, comprising: an elongated bar having parallel sides and having an outer surface transversely curved and convexly bowed in an axial direction, a ring segment fixed on one side of the bar intermediate the ends thereof and cooperating with the transversely curved surface to define an arc of a circle, a projection on the extending end of the ring segment, the bar having a notch on the other side shaped to receive a similar projection.

No references cited.