June 5, 1962 H. E. McGOWEN, JR., ETAL 3,037,558

WELL PLUNGER

Filed Oct. 12, 1959 3 Sheets-Sheet 1

Fig. 1

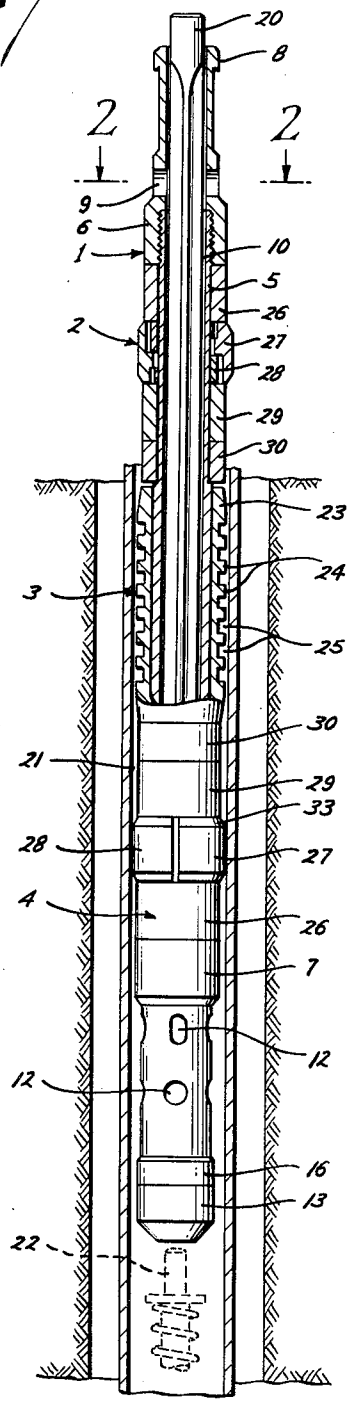


Fig. 3

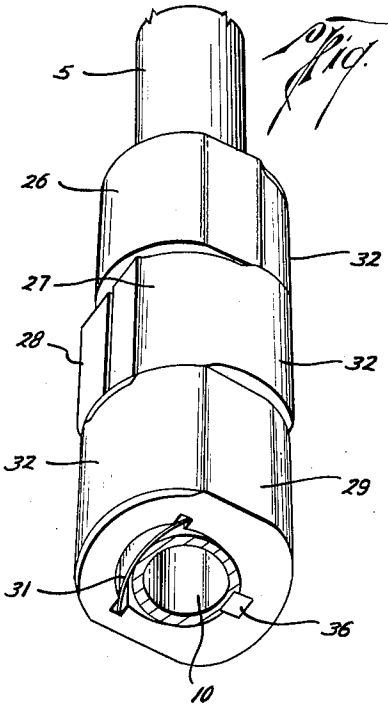
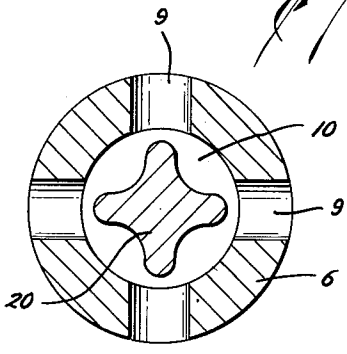


Fig. 2



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Filed Oct. 12, 1959 3 Sheets-Sheet 2

Fig. 4

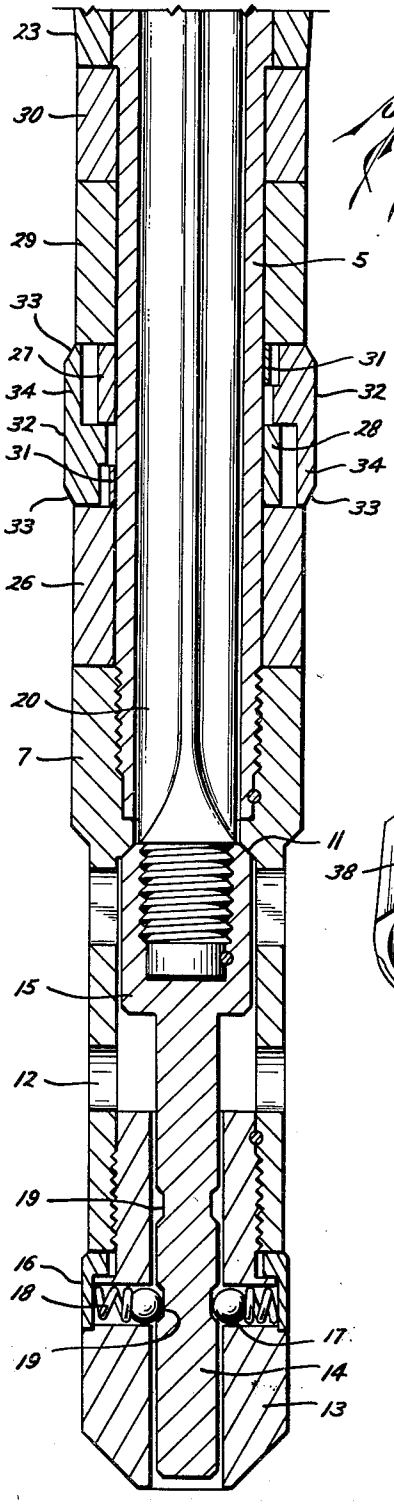
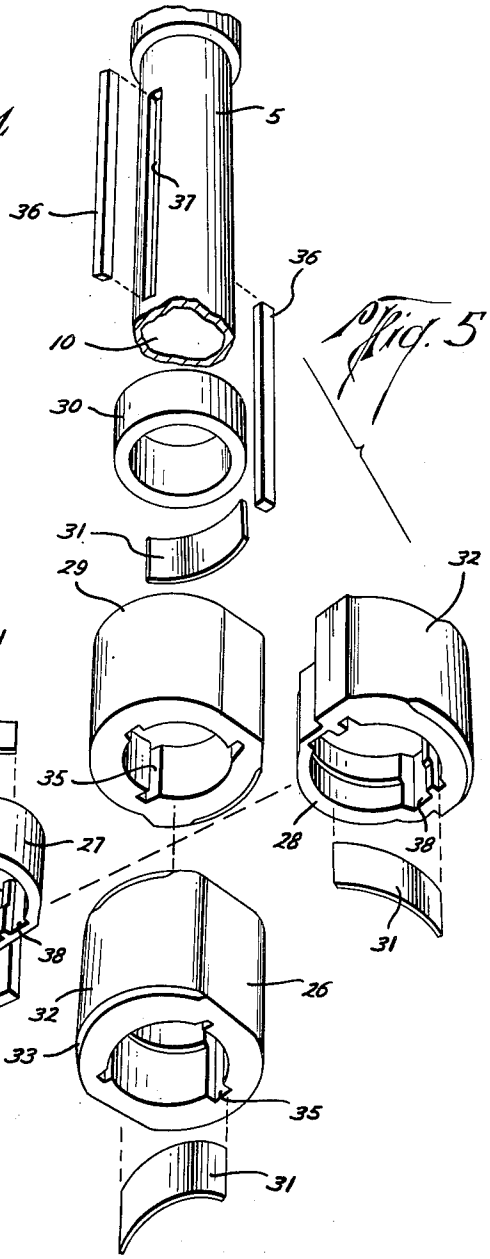


Fig. 5



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Filed Oct. 12, 1959 3 Sheets-Sheet 3

Fig. 6

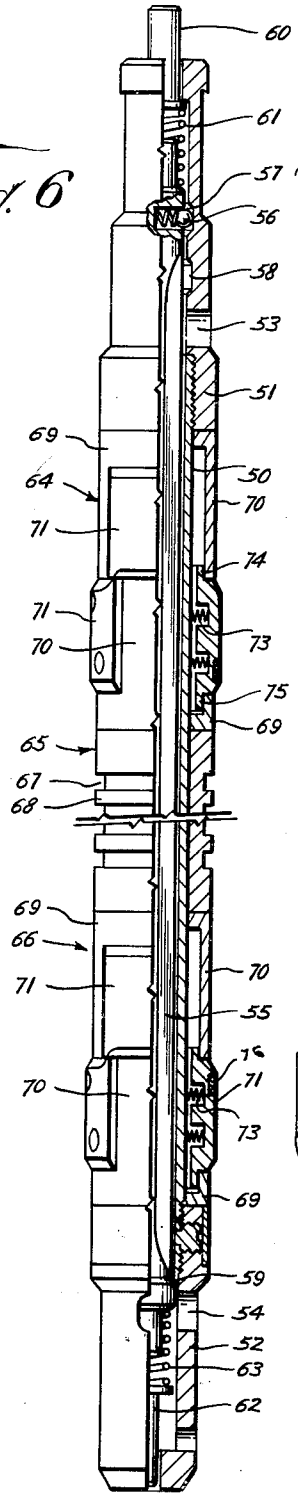
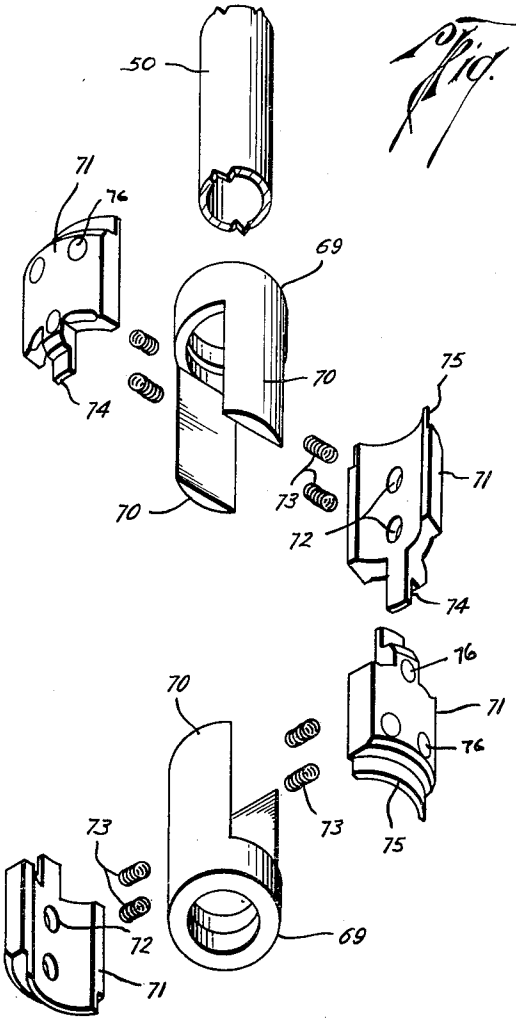


Fig. 7



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3,037,558

WELL PLUNGER

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3 Claims. (Cl. 166—170)

This invention relates to well plungers and more particularly to an improved free plunger which travels within a well fluid production tubing string with a close peripheral slide bearing thereon to block fluid flow around the plunger and which has a passage in flow by-pass relation with the closely fitted periphery and for control by a valve whereby the plunger can drop by gravity when the passage is open and can be raised under action of fluid pressure when the valve is closed for return to latched reception within a part of the Christmas tree at the well head.

An object of the invention is to provide improved peripheral surface formations on a free plunger to co-operate throughout its circumference with the wall of the tubing string during plunger travel for guide centering and exteriorly sealing the plunger with the tubing and for scraping, removing and precluding excessive buildup of wall coating deposits of paraffin or the like.

A further object of the invention is to provide a plunger having a group of outwardly biased well bearing segments nonrotatably positioned on the plunger and confined to resiliently urged outward movement in directions angularly spaced one to another and each of an arcuate length to co-operate with other adjacent segments in all lateral expansive positions for a combined contact with the well tubing wall throughout its entire circumference.

Another object of the invention is to provide a plunger having two sets of resilient seal bearing segments and an intermediate group of peripheral grooves spaced apart by annular ribs and active as a turbulence producing seal which is resistant to fluid blow-by and complements and co-operates with the resilient contact seals above and below the ribs.

Other objects and advantages of the invention will become apparent upon inspection of the accompanying drawings illustrating a preferred but not necessarily the only embodiment of the invention and wherein FIG. 1 is a side elevation with parts in transverse section of a free plunger with the parts positioned for upward travel in a well tubing string; FIG. 2 is a transverse section on line 2—2 of FIG. 1; FIG. 3 is a perspective view of a subassembly stack of flexible sealing collars; FIG. 4 is a transverse section through a lower fragment of the running tool shown in FIG. 1 and on a larger scale; FIG. 5 is a perspective view showing the several parts of a flexible seal unit in exploded relationship; FIG. 6 shows an alternative plunger unit in elevation and half in longitudinal section; and FIG. 7 is a perspective view of the scraper seal subassembly according to FIG. 6 and in exploded relation.

The improved plunger as illustrated in FIG. 1 includes an elongated hollow body or tubular assembly 1 on which are successively sleeved an upper flexible seal unit 2 comprising a stack of relatively laterally shiftable collars having outwardly disposed regmental wiper faces in circumferentially spaced apart relation one to another; an intermediate seal unit 3 having a series of peripheral and alternately arranged grooves and ribs which act during plunger travel to entrap fluid and create turbulence thereof for minimizing fluid slippage; and a lower flexible seal unit 4 which structurally duplicates the upper seal unit 2.

The hollow body 1 is made up of a long barrel 5 on which the sealing units 2, 3 and 4 are successively sleeved and held between retaining nuts or tubular couplers 6 and 7 having threaded connection on opposite ends of the barrel 5 and constituting continuations thereof. The upper coupler 6 conveniently terminates in a fishing head 8 and the side wall below the head contains one or more lateral openings 9 as flow ports communicating the internal bore or passage 10 in the barrel with the exterior of the plunger above the seal units. Below its barrel connection, the lower coupler tube 7 has an internal tapered or frusto-conical seat 11 (see FIG. 4) for a two-position passage control valve and the coupler side wall below the valve seat has one or more lateral ports 12 for barrel passage communication with the plunger exterior below the seal units.

Secured as by a screw thread connection within the bottom of the coupler sleeve 7 is a nose fitting 13 having a bore therethrough axially aligned with the barrel passage 10 and slidably guiding a dependent stem 14 on an enlarged head 15 caged for reciprocation within the coupler tube 7 and terminated upwardly in an annular valving surface tapered in mating relation to and for bearing co-operation on the tapered seat 11. Clamped between the bottom of the valve caging coupler 7 and an external shoulder on the nose fitting 13, is an internal annular flange of a band 16 which exteriorly overlies and closes the outer ends of a pair of small openings drilled radially through the nose fitting for housing inwardly spring pressed poppets or ball detents 17 and compression coil springs 18 interposed between the detents and the closure band 16. The inwardly pressed poppets 17 co-operate alternately with one or the other of a pair of annular keeper grooves 19 cut into the dependent valve stem 14 in axially spaced apart relation at opposite valve stroke limits. With the poppets seated within the lowermost groove 19, they yieldably maintain the valve 15 engaged with its seat, as is seen in the drawing. Valve travel out of seating engagement brings the uppermost keeper groove into alignment with and for reception of the poppets 17 whereby displacement from valve open position is yieldably resisted.

Threaded at its lower end into a pocket of the valve head 15 and projected upwardly through the passage 10 is a rod 20 preferably of X-shape in cross section for strength without undue restriction of the flow passage between the valve open position and the side ports 9 at the upper end of the passage. In axial length the rod 20 is such that its tip, as seen in FIG. 1, projects above the fishing head 8 a distance to approximate the axial spacing between the keeper grooves 19. This will facilitate depression at the upwardly projected tip of the valve and its stems relative to the barrel and transfer of the spring pressed poppet 17 from the lower groove to the upper groove 19 in a valve unseating operation.

Similarly the dependent valve stem 14 is of a length that its terminal tip on being depressed from retracted position with the valve closed, as seen in FIG. 4, to the valve open position, will be projected beyond the fitting 13 a distance convenient for striking an abutment and accommodating relative barrel down movement and return of the valve seat 11 into engagement with the valve head 15 and passage closing position. Such control of the valve head is effected at the opposite limits of plunger travel within the production tubing string 21. At the lower limit of plunger travel, the downwardly projected stem 14 of the unseated valve will come into engagement with a suitable spring cushioned abutment 22, illustrated by broken lines in FIG. 1, and will be stopped while the valve seat 11 continues downwardly with the barrel until valve closing engagement occurs. At the upper limit of plunger travel, the upwardly projected valve stem rod 20 of the then seated valve head will strike a fixed abutment for stopping its upward travel while the barrel and valve seat 11 move further upward for raising the seat 11 off of the valve head 15. The extent of relative valve unseating travel is limited by stop abut-

ment of the upper edge of the nose **13** with the bottom shoulder of the enlarged head **15**.

Fluid blow-by between the periphery of the plunger and the tubing string interior is minimized by the seal assemblies **2**, **3** and **4**. The seal **3** is essentially a sleeve **23** closely fitted to an intermediate portion of the barrel **5** and provided peripherally with a series of alternate ribs **24** and grooves **25**. In diameter, the ribs **24** are slightly smaller than the inside diameter of the tubing string and by way of example, a circular clearance of approximately one-sixteenth of an inch has been found satisfactory. Groove and rib width and groove depth can vary but should be within limits to afford fluid passage resistance by reason of turbulence generated between the tube surface and the alternately large and restricted clearances afforded by the grooves and ribs on the sleeve **23**.

The seal assemblies **2** and **4** each consists of a stack of four collars **26**, **27**, **28** and **29** sleeved in tandem succession on the barrel with adjacent end faces of adjoining collars in lateral slide bearing abutment with one another. The lowermost end face of the lower collar **29** of the upper assembly **2** has lateral slide bearing abutment with a spacer ring **30** closely fitted on the barrel and seated downwardly on an external barrel shoulder. The upper end face of the uppermost collar **26** has lateral slide bearing abutment with the bottom edge of the coupler **6**, which also holds the stack of collars in place. Similarly, the co-operating collars of the unit **4**, which are identical to those of the unit **2** and are here given the same reference characters, are held between a spacer ring **30** and the coupler **7** with lateral slide bearing at their end faces.

The central opening through each collar is generally elliptical or ovaloid, as can best be appreciated in FIG. 3, and when fitted to the tubular barrel **1** gives lateral clearance by which collar displacement can take place. On one side of the tubular barrel axis, the elliptical opening follows a curve on approximately the same radius as that of the barrel periphery so that the surfaces mate. These surfaces can move apart or they can seat on one another, as illustrated in FIG. 3, to limit outward collar displacement in one lateral direction. The radius of the remainder of the oval opening is generally of increasing dimension for providing lateral clearance with the barrel on the side thereof opposite the region affording collar contact limit surface and on the major axis of the ellipse. Housed within the clearance recess is a bowed spring blade **31** which centrally of its opposite ends bears inwardly on the barrel and at opposite ends is received within longitudinally extending locating grooves in the collar wall and bears outwardly under elastic stress on the grooved sides. Spring force biases the collar laterally in the direction of the major axis of the ellipse and toward an outward limit afforded by the contacting surfaces of the barrel and collar, as viewed in FIG. 3. For minimum clearance, the outside diametrical dimension of each collar is only slightly smaller than the inside diameter of the tube in which the plunger is to travel. Additionally, the collar periphery is out of round and in eccentric relation to the barrel. The external shape includes a side face portion or segment **32** outwardly offset from the collar periphery generally and on the side outwardly from the clearance recess. It extends throughout collar length and throughout at least and preferably slightly more than forty-five degrees on each side of the major axis of the elliptical opening. The offset face **32** is machined as a segment of a circle or cylinder conforming substantially to the circular outline of the tubing interior. Thus there is provided on the outer side of the collar a segment of a cylinder throughout an angle of ninety degrees, more or less, and which under spring bias is constantly urged laterally outwardly from the barrel axis. By confining the set of four collars constituting the seal unit against relative rotation and for projection on radial lines ninety degrees apart, the combined lengths of the circular succession of outwardly offset segmental faces will extend throughout the entire three hundred sixty degree tube circumference. In fully or nearly fully expanded positions as predetermined for standard tubing dimensions, plunger travel will drag the several outwardly pressed segmental faces of the collars in wiping or bearing contact with and around the full circle of the tubing surface for co-operation therewith and with one another. The collars, in both their bearing and nonbearing segment faces, combine to seal or reduce fluid leakage around the plunger by both contact and labyrinth fit to the tubing. Wiping contact scrapes off paraffin or other coating deposits which otherwise might build up and restrict the flow volume of the tubing string.

Each of the outer bearing faces **32** on the arcuate segments of the shiftable collars has top and bottom edges beveled, as seen at **33**, for eliminating abrupt and outwardly projecting shoulders and for insuring easy passage past tubing surface irregularities such as occur at tubing joints. Hang-up of the plunger in internal clearances in the tubing is further minimized by the controlled limited outward relative expansion of the collars to preclude outward displacement of the outer bearing faces **32** appreciably beyond the tube interior surface. The extent of spring biased outward projection is selected by design beforehand in relation to tube diameters and with necessary tolerance to compensate for wear, whereby there will be afforded a snug but yieldable interface contact during plunger travel.

For axial compactness, the centermost pair of a set of four or more collars are formed for an internested and overlapped relation. Each collar of the centrally located pair may be considered as being of full length throughout approximately half of its circumference and of half length throughout the remainder of its circumference, with the latter also being of reduced external diameter and with the wall of the long half being relatively thin and relieved on the inside thereof in the region which projects longitudinally beyond transverse alignment with the smaller length half. In other words, the complete circular collar includes a full circle ring in half its length and a longitudinally projected half circular side lug **34**. The wiping surface **32** is formed on both the projecting lug and the adjoining collar wall portion and its length, as desired, can be similar to the lengths of the endmost collars **26** and **29** for balanced contact areas on the several collars. When these centermost collars **27** and **28** are brought together with their lugs **34** extended oppositely to one another and on diametrically opposite sides from one another, the collars will be in a nested relationship, as is best seen in FIG. 4.

In final assembly, the centermost and nested collars **27** and **28** move laterally on a common diametrical line, their respective springs urging them outwardly in opposite directions. The endmost collars can then be arranged for spring urged movement in opposite directions on a diametrical line angularly spaced ninety degrees from the line of movement of the centermost collars. Accordingly, the arcuate tube bearing faces **32** will be urged outwardly, each in a different angular direction spaced ninety degrees from one another; and since the circular extent of each such face of the four segments is an arc of approximately ninety degrees (the segment faces of the collars **26** and **29** can be extended more than ninety degrees if desired), the several faces combined will make contact continuously throughout the circumference of the tubing string.

The several collars are keyed to the barrel **5** for guiding each collar in its selected lateral direction. Each endmost collar is provided interiorly with a keyway, as shown at **35** in FIG. 5, whose sides are parallel to the side travel direction. They have close slide reception of one of a pair of longitudinally extending keys **36** fitted to grooves or keyways **37** in the barrel **5**. The two keys **36** extend into both of the centermost collars and are received

within keyways 38 of greater width than the keys 36. These wider keyways 38 extend outwardly substantially at right angles to the desired direction of collar movement but inasmuch as the keyways are wider than are the keys, there is no interference with the limited lateral movement required. Flat surface bearing contact between the bases of the keyways 38 and outer faces of both keys 36 confines these collars against rotation on the barrel.

As previously indicated, the plunger will descend in the tubing string when the by-pass valve is open and allows balancing pressures on opposite sides thereof and will rise in the tubing string when the valve has been closed, and in response to fluid pressure beneath the plunger. Either natural well pressure or artificial lift pressure controlled at the surface will impart upward travel to the plunger for unloading liquids thereabove, as is often helpful in the operation of oil and/or gas wells. In each travel direction, the tubing surface, by reason of the bearing seals, will be cleaned of excessive paraffin deposits. More particularly, the flexible seal units provide a wide metal sealing surface that can flex from drift diameter to nominal tubing inside diameter while maintaining a complete or substantially complete three hundred sixty degree contact. Such flexing and yieldable fit minimizes undesirable turbulence and allows faster upward travel of the plunger and liquid slug for reducing liquid fallback. The wide area sealing surface prevents the likelihood of the plunger hanging or grabbing in coupling gaps. The plunger as illustrated can be operated in existing installations and which include conventional surface controls for timing the drop of the plunger and the catching of the plunger on arrival at the surface.

In the alternative plunger embodiment of FIGS. 6 and 7, there is a hollow tube or mounting body 50 coupled at top and bottom to upper and lower end tubular portions 51 and 52 which co-operate with the mounting tube 50 in providing a flow passage through side ports 53 and 54 respectively. Slidably extended through the tube 50 and its end coupler heads 51 and 52 is a longitudinally grooved rod or valve stem 55 carrying a spring pressed and laterally biased poppet or detent 56 at its upper end for co-operation with a pair of axially spaced apart internal grooves 57 and 58 in the head 51. Near its lower end, the valve stem has an annular enlargement or head providing an upper tapered valve seat 59 to co-operate with a mating seat afforded by the bottom edge of the tube 50 for closing a central flow passage when the poppet 56 is in the upper groove 57, as shown in the drawing.

At the upward limit of plunger travel an abutment pin 60 slidably mounted in and projected above the top of the head 51 will engage a suitable stop and resistance to further movement as cushioned by a coil spring 61 interposed between the abutment pin 60 and the upper end of the rod 55 will allow retraction of the poppet detent 56 from the upper groove 57 until relative tube slide travel brings the lower groove 58 into alignment with the poppet detent for the reception thereof. At such time, the tube carried valve seat will have raised itself above the valve head seat 59 for relieving pressure below the plunger for its return descent in a production conduit. At the downward limit of plunger travel, a stop abutment will be struck by the then downwardly projected bottom pin 62 and the resulting force will be cushioned by a coil spring 63 and effect a reseating of the valve head seat 59.

Mounted exteriorly on the central tube 5 and retained in assembly by the opposite end couplings 51 and 52, are sealing assemblies 64, 65 and 66 arranged in end to end succession. The intermediate sealing assembly is a sleeve having a series of peripheral grooves 67 separated by spaced apart annular ribs 68 for co-operation with the wall of a tubing string in providing resistance to fluid passage by the creation of fluid turbulence at the alternate zones of close and wide clearances provided by the annular grooves and ribs.

The upper and lower seal assemblies 64 and 66 are of like structure. Each consists of a pair of sleeves in end to end succession, with each sleeve having a pair of diametrically opposite openings or windows in an end portion thereof, as best illustrated in FIG. 7. Each opening extends from one end of the sleeve to a region near its opposite end and thereby forms an annular ring or band 69 for encircling the tube 50 and a pair of opposed longitudinally extending legs 70 dependent from the circular band 69.

The interior surfaces of the two legs 70 are machined flat and the two plane surfaces are parallel to one another. They provide guide bearing surfaces for the opposite sides of a pair of shoe segments 71 diametrically oppositely related and positioned so that their outer arcuate faces project slightly radially beyond the periphery of the end band 69 in the final assembled relation of parts. The outer arcuate surface of each shoe will approximate the shape of the cylindrical surface of the tubing string in which the plunger is to operate. A set of three suitably spaced apart peripheral recesses are preferably formed in each shoe and receive staked-in discs 76 of carbide or other relatively hard wear resistant material whose outer faces are for slide bearing co-operation with the interior of a tubing string and are substantially flush with the outer face of the shoe.

Each shoe segment 71 has one or more internal depressions 72 and each depression provides a locating pocket for one end of a coil spring 73 whose opposite end engages with the mounting tube 50 for resiliently urging the shoe segment outwardly as guided by its side engagement with the dependent legs 70. To limit its outward range of expansion, each shoe 71 has a longitudinally projecting end tab or retainer tongue 74 to underlie an adjacent end of an adjoining dependent leg 70 of the other sleeve of the cooperating pair, and also has an axially projected flange 75 near its inner surface to underlie an adjacent counterbored portion of the locating ring 69.

Each shoe segment will extend through an arc somewhat more than ninety degrees and the oppositely disposed shoe segments of one pair will be staggered or disposed at a ninety degree angular relation with the other cooperating and axially spaced pair of shoe segments. This angular relationship will therefore provide a bearing surface throughout the entire three hundred sixty degrees of a tubing string in which the plunger is to operate. Such full circular slide bearing will be provided by the assemblies 64 and 66, both above and below the turbulence sleeve 65, and the several sealing elements will cooperate to restrict fluid leakage around the plunger on the valve closed upstroke and the wiping contact with the tubing string will scrape paraffin accumulations from the surface and keep the surface clean of appreciable restriction to full open fluid flow.

What is claimed is:

1. In a well tubing plunger, a central mounting tube, a pair of companion sleeves surrounding the tube in end to end relation one to another and each having in an end portion adjacent the other a pair of diametrically opposed openings spaced approximately ninety degrees from the openings in the other sleeve and projected from one sleeve end to a point short of the other sleeve end to define a pair of oppositely disposed side legs depending from a tube encircling ring at said other sleeve end, a laterally shiftable shoe segment positioned in each of said openings and guided at its sides by side bearing engagement thereof with the depending side legs, elastic means biasing the shoe segments radially outwardly and retainer tongues projecting from the top and bottom of each shoe segment to underlie adjoining leg and ring portions.

2. In a well tubing plunger of the character described, a mounting tube, a plurality of laterally shiftable shoe segments arranged in longitudinally successive pairs, with the segments of one pair spaced ninety degrees from the segments of another pair and with the segments of each

pair diametrically oppositely disposed, sleeve means for mounting each pair of said shoe segments on the tube including a tube encircling band having a pair of dependent and circularly spaced apart legs slidably fitted to a pair of shoe segments along the sides thereof, spring means elastically urging the shoe segments radially outwardly between said legs and laterally overlapping retainer surfaces on the shoe segments and said sleeve means limiting outward shoe segment travel.

3. A free plunger for travel in a well tubing, including a long hollow central member providing a longitudinal passageway therethrough and having enlarged head portions at opposite ends and a valve seat in said passageway, a reciprocatory valve slidable in the passageway toward and from passageway closing relation with said seat and means blocking fluid passage over the exterior of the plunger and comprising at least two longitudinally successive sets of diametrically opposed tubing scraper segments disposed with the segments of adjoining sets angularly spaced apart, segment retainer collars sleeved on said central member and clamped in longitudinal succession

between said enlarged head portions, each retainer collar having longitudinal leg extensions and oppositely disposed side window openings between said leg extensions and extending through one end of the retainer collar for reception of a set of segments whose sides are laterally slidably fitted to the inside faces of said leg extensions, spring means bearing on each segment and urging the same outwardly and top and bottom retainer extensions on each segment respectively underlying the collar at one end of the window in which the segment is fitted and an adjacent leg extension of an adjoining collar as limit stops to outward displacement of the segment.

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