

[54] POLISH ROD STUFFING BOX CAVITY

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[22] Filed: Dec. 30, 1971

[21] Appl. No.: 214,172

[52] U.S. Cl..... 166/315, 166/84

[51] Int. Cl. E21b 33/03, E21b 43/00

[58] **Field of Search**..... 166/314, 315, 84,
166/85

[56] **References Cited**

UNITED STATES PATENTS

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[57] **ABSTRACT**

The invention concerns apparatus and method enabling conversion of a short stroke well pumping unit to long stroke operation. Cylindrical casing or the equivalent, which may be set underground, contains a stuffing box adapted to pass a wire line reciprocated polish rod, which suspends the rod string. A flow line extends within the casing to receive well fluid flowing upwardly via tubing extending below the stuffing box, and to by-pass the flow upwardly around the stuffing box. The latter, when installed underground, is remotely adjustable.

16 Claims, 5 Drawing Figures

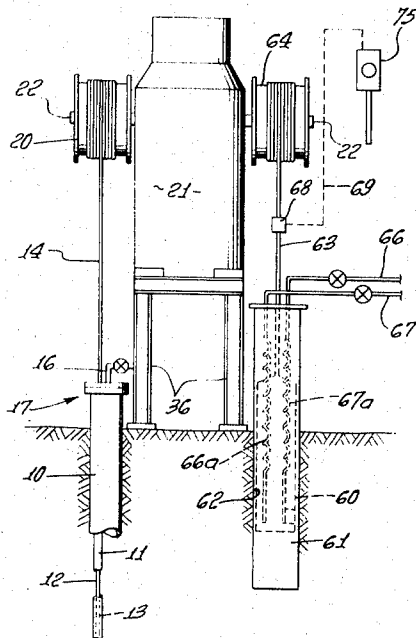


FIG. 1.

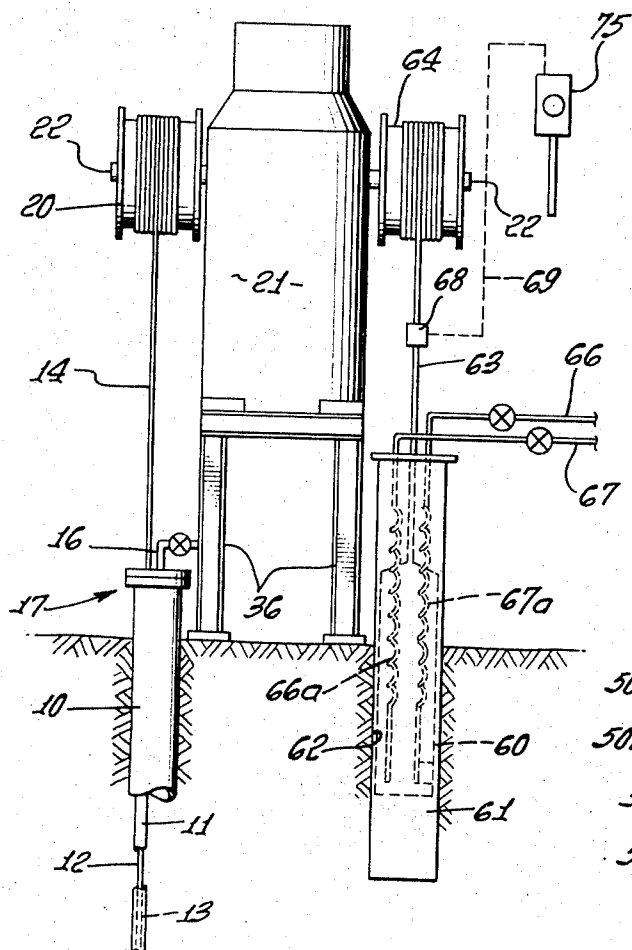


FIG. 3.

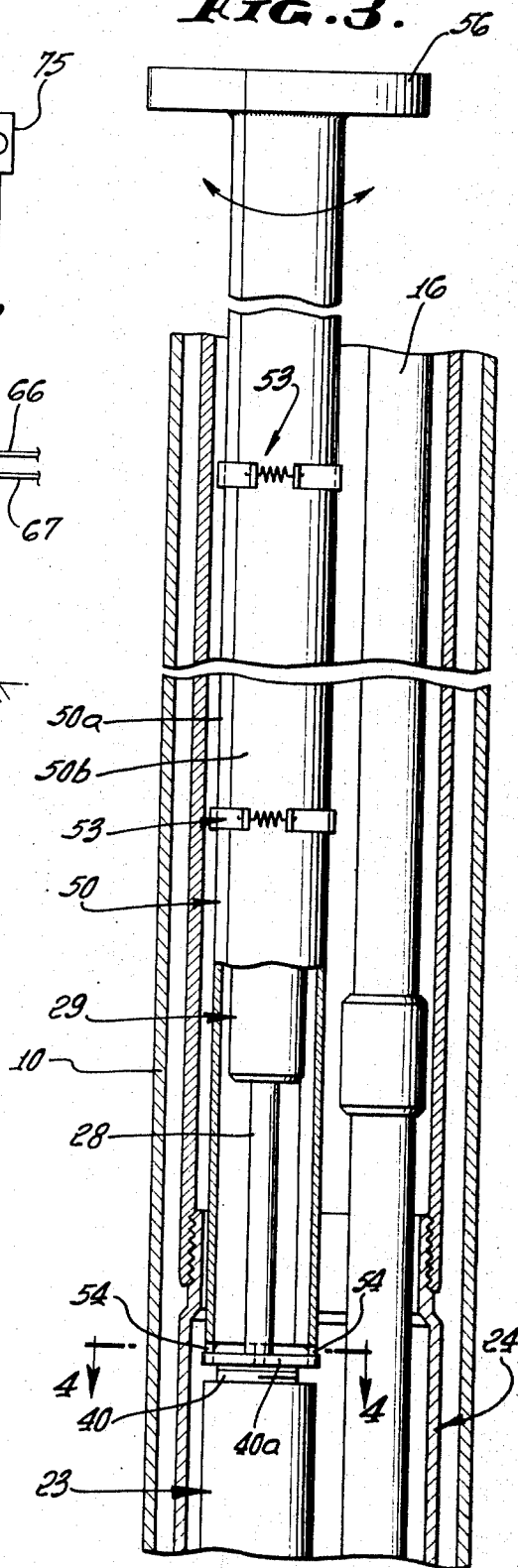


FIG. 4.

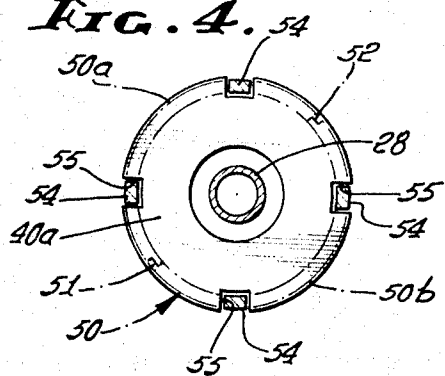


FIG. 2a.

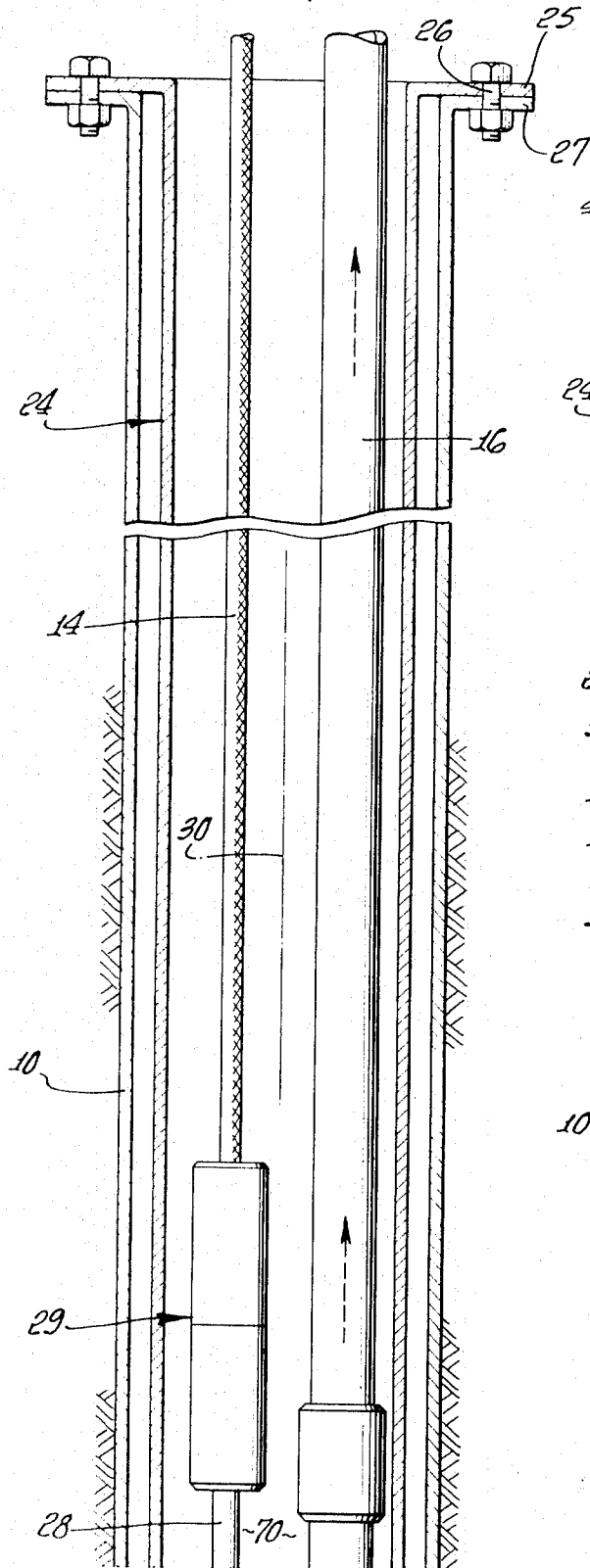
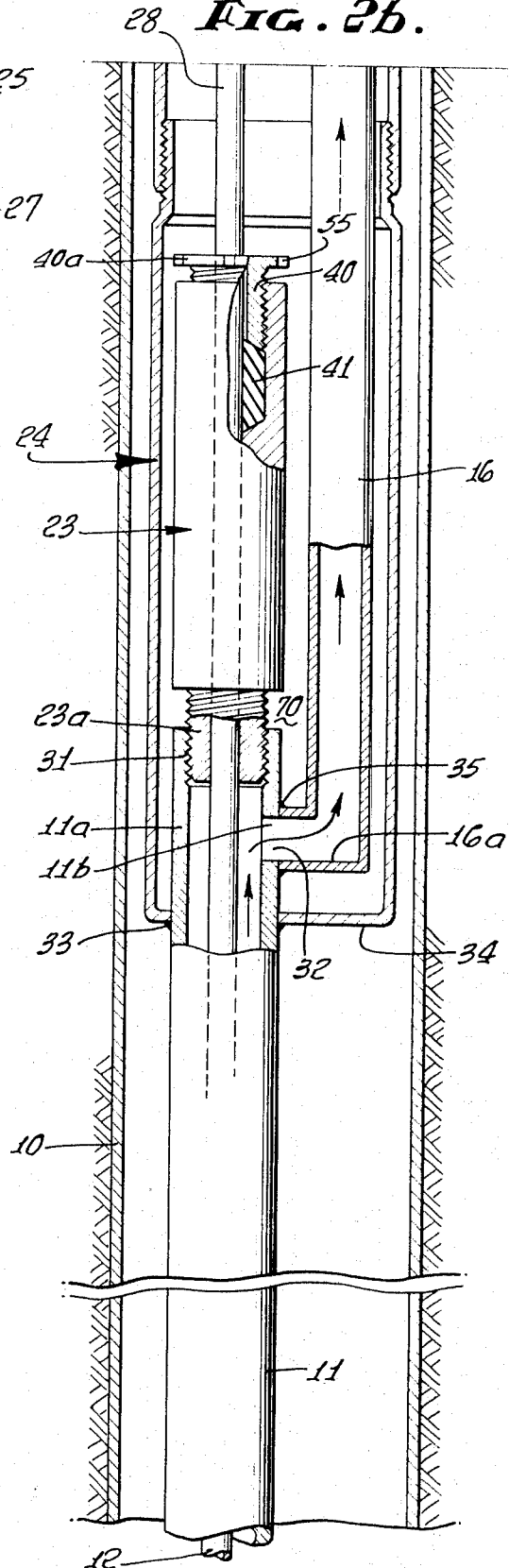


FIG. 2b.



POLISH ROD STUFFING BOX CAVITY

BACKGROUND OF THE INVENTION

This invention relates generally to the pumping of wells such as oil wells. More particularly it concerns the installation of wire line pumping equipment enabling pack-off at an underground location.

Oil production engineers everywhere are aware that the machinery being used by the oil producing industry to raise fluid from the well bore to the surface is far from being efficient, and the cost of raising a barrel of fluid to the surface is a factor they all have to reckon with. An efficient pumping operation is one that has the proper size surface lifting machinery and power source along with the right size down hole pump and the right tubing and rod string to keep the fluid pumped down to the pump shoe depth, the fluid column and the rod string counter balanced at the surface to effect a minimum of power consumption. This type of operation is almost impossible to accomplish with the surface lifting machinery that is currently being used on many thousands of wells, unless there is a constant reading on the depth of the fluid in the well bore and a constant changing of counter balances on the units and constant changes of the strokes per minute, all of which changes are extremely difficult or too costly to implement.

It would be safe to say there are no 100 percent efficient pumping operations with beam-type, counter-balanced pumping units, the reasons being the following:

If a well counter-balanced polish rod load is raising fluid from the pump shoe depth and it is not pounding fluid and the bottom hole pump is operating at 100 percent efficiency, the operation would be efficient until the first pump wear would start. A bottom hole pump is subject to wear from the first stroke it makes, so that after a few strokes the pump starts to lose some of its efficiency. Fluid in the well bore will start to accumulate over the pump, decreasing efficiency; and to capture the fluid over the pump the counter balanced unit must be speeded up in its number of strokes per minute, or the stroke must be lengthened. If the power source is a combustion engine, speeding up the unit is quite simple; however if the power source is electrical, a lengthy operation of changing the pulleys on the electric motor is required. If the well is a large volume producer, 4 or 5 hours down time will cause fluid accumulation over the pump that may require many days and even weeks in order to pull the fluid down to the pump shoe level. In the meantime, the pumping operation is out of balance and causing excessive power consumption and useless wear and tear on surface and down hole equipment. This description would characterize an under pumping operation.

In order to overcome the above mentioned problem, some production men go to oversized surface and down hole equipment that has the capacity of keeping the fluid pumped down to the shoe depth at all times. This type of operation will recover the fluid; however, there can be no greater damaging force to surface and down hole equipment than over pumping a well. Raising a column of fluid along with the weight of a rod string and dropping it back on a void or a semi-void is the direct cause of many surface and down hole equipment failures. For an example, if the polish rod load weighs 10,000 lbs. and the unit is making 10 strokes a minute, in a year's time this load is dropped back on to the tub-

ing string 5,256,000 times. Tubing, rod strings, down hole pumps, and surface machinery pay a big price for this type of pumping operation as well as oil cleaning chemical costs to demulsify the fluid pumped from the well. There can be little doubt that this type of over pumping operation is the cause of rod wear and fatigue tubing wear and collar leaks, excessive wear especially to balls and seats in the bottom hole pump, and it is safe to state that if a fluid log reading shows over a long period of time that the fluid is at the shoe, the well is being over pumped.

Many of the problems of under pumping and over pumping can be overcome with a long stroke pumping unit having a control system that causes the pumping unit to either speed up or slow down at the command of the fluid column in the well bore, i.e., the fluid level in the bore controls the operation of the surface machinery that pumps the well. See in this regard U.S. Pat. Nos. 3,516,762 and 3,521,445. If the fluid is at the shoe, the control causes the unit to slow down. If there is a fluid column over the pump, the control system causes the unit to speed up. If the fluid is surging in the well bore, the control system will speed up and slow down with the surge. Besides controlling the surface machinery to cause an efficient pumping operation, the control instrument will produce a graph and charts that will relate the depth of the fluid in the well at all times. It will show the number of strokes per minute and it will show when pump is losing efficiency.

A problem which remains is that of packing off the wire line pumping equipment, at an underground location. For example, operating a wire line pumping unit requires packing off the line, presenting a serious problem where a long stroke pumping unit is required for efficiency, the pack-off location being deep underground. Typically, the wire line is spooled on a surface drum and suspends a polish rod working in a stuffing box, the rod in turn suspending the well rod string. Satisfactory underground installation of the stuffing box and polish rod has not been possible due to the resultant inaccessibility of the stuffing box which requires adjustment to prevent leakage.

SUMMARY OF THE INVENTION

It is a major object of the invention to provide a solution to the above and other problems encountered in installing and operating wire line pumping units, underground. Basically, the invention is embodied in apparatus that comprises:

- a. a stuffing box adapted to pass a polish rod vertically suspended and reciprocated by a wire line, with the rod in turn suspending and reciprocating a pumping rod string in well tubing,
- b. cylindrical means containing said stuffing box and vertically elongated to receive the vertically reciprocated polish rod and to extend above the tubing containing the rod string, and
- c. a flow line extending within said cylindrical means and having a side port below the level of the stuffing box to pass well fluid flowing upwardly from the well tubing and in upwardly by-passing relation to the stuffing box within said cylindrical means.

As will be seen the cylindrical means may comprise inner and outer cylindrical casings, the inner supporting the stuffing box so as to be capable of being lowered into the outer casing (which extends underground) for removable support by the outer casing. Further, the

inner casing may then suspend the well production tubing directly below the stuffing box, there being space alongside the latter for a flow line branching laterally and then extending upwardly in the inner casing so as not to interfere with reciprocation of the polish rod, the whole assembly being upwardly removable from the outer casing, as desired.

Further, the wire line may be spooled on a drum at the surface, these being drive means to rotate the drum in opposite rotary directions as required for pumping the well; also, adjustable weight structure may be coupled to exert torque on the drum, in counter-balancing relation to the weight suspended by the wire line and exerting suspension torque on the drum.

Additionally, it is an important object to provide adjusting means insertible downwardly into the cylindrical casing and into releasable engagement with an adjusting element movable at the top of the stuffing box to adjust the polish rod pack-off, thereby to prevent leakage through the box. Such adjusting means may advantageously comprise a split tubular component removable assembled about the wire line to be displaced vertically thereof into and out of engagement with the adjusting element on the box.

Finally, it is an important object to provide an unusually advantageous method for adjusting an underground stuffing box by insertion and displacement of adjusting means vertically of and along the wire line, as will be seen.

These and other objects and advantages of the invention, as well as the details of an illustration embodiment, will be more fully understood from the following description and drawings, in which:

DRAWING DESCRIPTION

FIG. 1 is a side elevation showing an installation incorporating the invention;

FIGS. 2a and 2b constitute an enlarged vertical elevation taken in section to show details of the invention;

FIG. 3 is a view like FIG. 2a, but also showing an adjustment step; and

FIG. 4 is a horizontal section taken on lines 4—4 of FIG. 3.

DETAILED DESCRIPTION

Referring to FIG. 1, the typical oil well illustrated has outer casing 10 and production tubing 11 extending therein. Carried within the lower extent of the tubing 11 is a pump means 13 which is vertically reciprocable in response to up and down travel of the cable 14 and rod string 12. The pump may comprise a piston or swab operable to elevate a column of production fluid toward flow line 16 extending from the casing head 17.

The cable 14 extends upwardly of the casing head to spool on winding drum 20 driven alternately in opposite directions by drive means such as beam type pumping unit gear box 21, with output shaft 22.

Extending the description to FIGS. 2a and 2b, a stuffing box 23 is located underground within cylindrical means, such as inner casing 24 lowered into outer casing 10 and supported as via inner casing top flange 25 bolted at 26 to outer casing top flange 27. The stuffing box passes a polish rod 28 which is vertically suspended by wire line 14, to which the rod is connection by cross-over connection 29. The rod in turn suspends and reciprocates the pumping rod string 12 in the well tubing 11.

The inner casing 24 is vertically elongated to receive the vertically reciprocated polish rod, in generally laterally offset relation to the central vertical axis 30 of that casing. The flow line 16 also extends within the interior 70 of casing 24, and has a side port at 32 directly below the box 23 to pass well fluid flowing upwardly from the production tubing 11, and in upwardly bypassing relation to the stuffing box. For this purpose, tubing 11 may have pin and box threaded connection at 31 to the stuffing box lower terminal 23a; the tubing upper terminal 11a being weld connected at 33 to the bottom wall 34 of the inner casing; and the flow line 16 may have a dog leg 16a weld connected at 35 to the tubing upper terminal 11a defining side port 11b.

Accordingly, the equipment within the inner casing 24 may be sunk underground despite the fact that a long pumping stroke is utilized, whereby the surface equipment including drum 20 and drive 21 need not be elevated but may remain in place on the ground, as for example on sub-base or supports 36. This in turn enables ready conversion of a walking beam, short stroke pumping unit to a long stroke unit, to substantially extend the useful lives of the rod string, sub-surface pump, etc. Furthermore, the advantages of use of a long stroke sucker rod string are realized, and the equipment may be readily installed underground in casing 10.

It should be noted that the flow line 16 extends upwardly within the inner casing in laterally offset relation to the wire line 14, so as not to interfere with vertical reciprocation of that line.

Referring now to FIGS. 2b and 3, the stuffing box has an adjusting element, as for example rotary nut or cap 40, movable at its upper end to adjust the polish rod pack-off. For example, as the nut or cap 40 is rotated in a tightening direction, it advances downwardly to squeeze packing 41 more tightly against the polish rod; conversely, as the nut or cap is rotated reversely, it relieves the squeeze of the packing on the rod. In this manner, leakage of well fluid upwardly through the gland afforded by the packing can be prevented or minimized.

The problem of gaining access to the confined cap or nut is solved by the provision of adjusting means inserted downwardly into the inner casing into releasable engagement with the adjusting element to move it for adjusting the pack-off. For example, the polish rod may first be run downwardly in the stuffing box, and the adjusting means may then be displaced on and downwardly along the wire line and into engagement with the adjusting element to move same as described. More specifically, the adjusting means may take the form of a longitudinally split tubular component 50 removably assembled about the wire line. Component 50 may comprise sections 50a and 50b with longitudinal edge engagement or interfit at stepped joints 51 and 52 along their lengths to form a tubular assembly guided along the wire line as it is advanced downwardly over the cross-over 29. Spring retainers 53 removably assembled over the made-up component sections 50a and 50b hold them in place during such downward advancement, carrying drive lugs 54 on the sections into interfitting relation with grooves 55 in flange 40a of cap or nut 40, for rotating the latter. Accordingly, the underground stuffing box may easily be adjusted by rotating the fitting 56 at the upper ends of the component sections, as by a torque wrench, after which the compo-

nent sections may be withdrawn. These operations may be carried out, if desired during continued pumping of the well.

Referring again to FIG. 1, adjustable weight structure may be provided to exert torque on the drum 20 in counter balancing relation to the weight suspended by the wire line and exerting suspension torque on that drum. Such structure may include a liquid reservoir positioned to be moved upwardly to downwardly as cable 14 moves downwardly and upwardly respectively, whereby the drive unit 21 including a suitably small motor need only supply minimum power to effect vertical reciprocation of the well pump, the need for large gasoline or Diesel engines being obviated. More specifically, the liquid reservoir or traveling tube 60 is accommodated for vertical movement within casing 61 in a bore or rat hole 62 drilled in the earth to a depth sufficient to permit maximum travel corresponding to selected ranges for the well pump. See in this regard U.S. Pat. No. 3,516,762.

Reservoir 60 is connected by cable 63 with the drive 21 as via a drum 64 also connected with shaft 22, the direction of spooling of cable 63 on drum 64 being opposite to that of cable 14 on drum 20. The quantity of liquid in reservoir 60 may be adjusted in weight compensating relation to variations in the load to be lifted in the well by cable 14, that load including the weight of the rod string, bottom hole pumping means 13, and the weight of the column of production fluid. Such adjustment may be had via liquid inlet and outlet conduits 66 and 67 having vertically flexible extensions 66a and 67a received downwardly into the reservoir 60.

A load cell 68 connected in series with cable 63 furnishes an electrical output at 69 indicative of loading imposed by the liquid reservoir 60. That output may be transmitted to a recorder 75 which may be calibrated to indicate the loading transmitted by the cell. Since the system is in approximate balance, the cell output also indicates the load imposed on wire line 14, and if the weight of the suspended equipment is subtracted at the indicator 75, the weight of the suspended column of well may be derived and displayed. Knowing the cross sectional area of the well tubing, the height of the column of liquid may also be derived and displayed.

I claim:

1. In well pumping apparatus, the combination comprising

- a. a stuffing box adapted to pass a polish rod vertically suspended and reciprocated by a wire line, with the rod in turn suspending and reciprocating a pumping rod string in well tubing,
- b. cylindrical means containing said stuffing box and vertically elongated to receive the vertically reciprocated polish rod and to extend above the tubing containing the rod string, and
- c. a flow line extending within said cylindrical means and having a side port below the level of the stuffing box to pass well fluid flowing upwardly from the well tubing and in upwardly by-passing relation to the stuffing box within said cylindrical means.

2. The combination of claim 1 wherein said cylindrical means comprises inner and outer casing members, the inner casing member supported by the outer casing member and supporting said stuffing box and flow line.

3. The combination of claim 2 including said well tubing suspended by the inner casing member below said flow line and stuffing box.

4. The combination of claim 1 wherein said flow line also branches laterally from said side port and then extends upwardly in said cylindrical means in laterally spaced relation to said stuffing box.

5. The combination of claim 4 including said polish rod extending vertically in said stuffing box.

6. The combination of claim 5 including a drum at the well head and said wire line suspending said polish rod and wound on the drum and drive means to rotate said drum forwardly and reversely.

7. The combination of claim 6 including adjustable weight structure exerting torque on said drum in counterbalancing relation to the weight suspended by said wire line, and exerting suspension torque on said drum.

8. The combination of claim 6 wherein the stuffing box has an adjusting element movable at the upper end thereof to adjust the polish rod pack-off, and adjusting means inserted downwardly into said cylindrical means into releasable engagement with said element to so move said element.

9. The combination of claim 8 wherein said means comprises a split tubular component removably assembled about said wire line to be displaced vertically thereof into and out of engagement with said element.

10. The combination of claim 9 wherein said component has rotary drive-lug interengagement with said element.

11. The combination of claim 1 wherein said cylindrical means extends underground and comprises inner and outer casings, the inner casing supported by the outer casing and supporting said stuffing box underground.

12. In well pumping apparatus comprising a stuffing box passing a polish rod suspended for vertical reciprocation by a wire line, the rod in turn suspending a pumping rod string for vertical reciprocation in well tubing, the stuffing box having an adjustment element movable at the upper end thereof to adjust the polish rod pack-off, the method including

- a. lowering the wire-line to run the polish rod downwardly in the stuffing box,
- b. moving said element to adjust the polish rod pack-off by displacing an adjusting means on and downwardly along the wire line and into engagement with said element and thereafter moving said adjusting means to so move said element, and thereafter withdrawing said adjusting means upwardly along the wire line to free the adjusting means from said element, and
- c. the stuffing box being maintained in a supported condition independently of the adjusting means.

13. The method of claim 12 wherein said box is located within upright cylindrical means having an upwardly exposed mouth, and wherein said adjusting means is assembled about said line and moved downwardly via said mouth into engagement with said element.

14. The method of claim 13 wherein said stuffing box is located at an underground level, and including the steps of carrying out said withdrawing step by displacing said adjusting means upwardly via said mouth, and thereafter reciprocating the wire line to effect pumping of the well.

15. The method of claim 13 wherein said adjusting means comprises a longitudinally split tubular component having sections, and wherein said assembly of said component on the wire line includes coupling said sections of said component about the line.

16. The method of claim 14 including the further step of passing well fluid upwardly within said cylindrical means and in upwardly by-passing relation to said stuffing box.

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