Aug. 4, 1964 W. N. SUTLIFF 3,143,080

DEEP WELL PUMP FOR VISCOUS OIL

Filed March 25, 1963

FIG. 1.

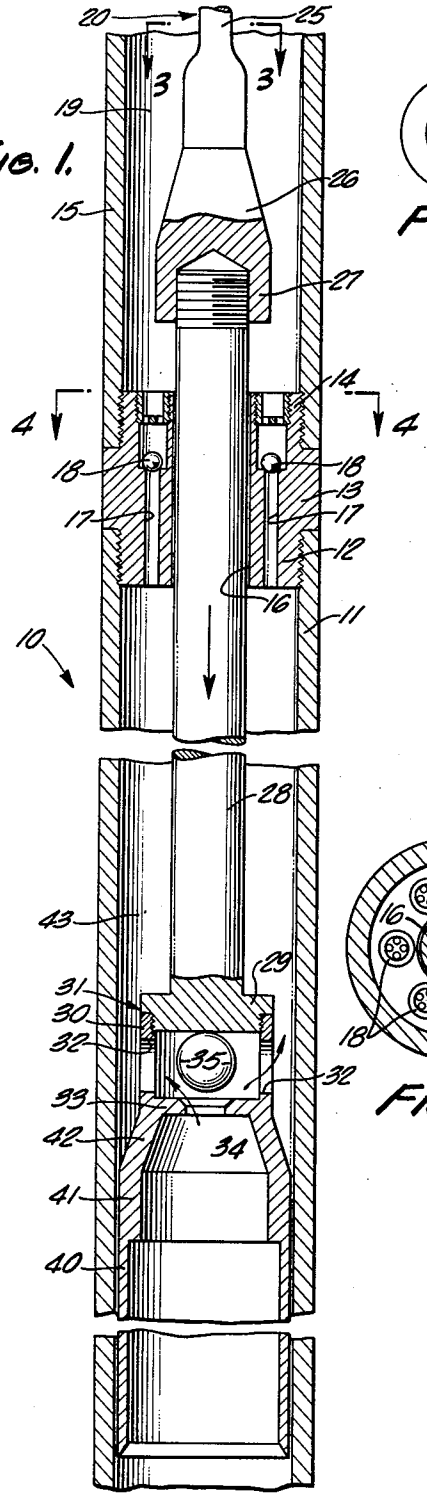


FIG. 3.

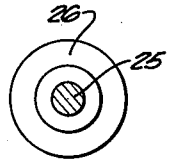


FIG. 2.

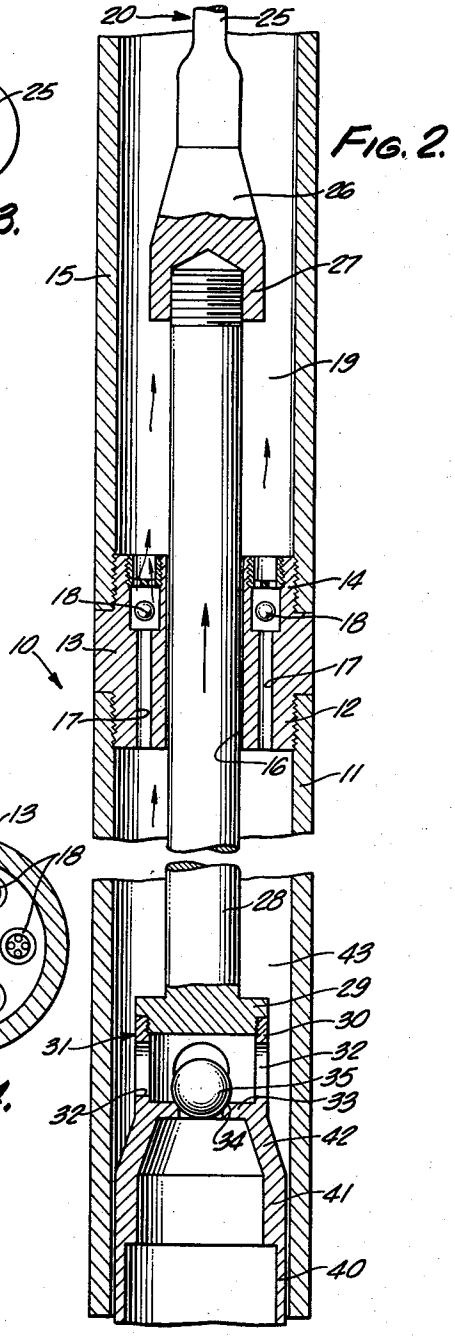
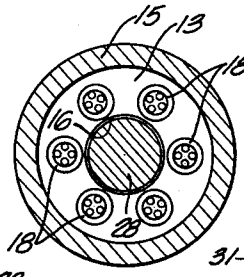


FIG. 4.



INVENTOR.
WAYNE N. SUTLIFF

BY

ATTORNEY

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DEEP WELL PUMP FOR VISCOUS OIL

Wayne N. Sutliff, 2931 Pierce Road, Bakersfield, Calif.

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This invention relates to the art of oil well production and particularly to production from wells in which the oil has a relatively high viscosity.

Discovery of new and important compounds derivable from natural petroleum with a high viscosity has recently awakened interest in improving the techniques of removing this type of oil from the ground. Thinning viscous oil by the addition of a solvent or by heating it have been extensively tried to expedite pumping this oil to the surface. These expedients have proved either too cumbersome and expensive or have introduced intolerable fire hazards.

It is accordingly an object of the present invention to provide an improved pump which is particularly adapted to pump relatively viscous oil from a deep well without the aid of these expedients.

One of the chief problems met with in pumping viscous petroleum from a well is the retarding of the return movement of the plunger in the pump barrel by the resistance set up in all portions of the pump by the viscous character of the production fluid. To solve this problem, heavy weights have been applied to the plunger but the effect of these weights greatly decreases where the bottom portion of a well inclines as much as 45° from vertical, and such an angle of inclination is not at all uncommon. Another expedient widely tried has been to apply a coiled spring to the plunger which is stretched or compressed on the upstroke of the plunger, the tensioned spring thus speeding up the downstroke of the plunger. This functions regardless of the angle at which the well is slanted but the spring can be made effective for only a relatively short stroke and the power applied varies radically from one end of the stroke to the other.

Another object of the present invention is to provide an improved deep well plunger pump incorporating means for increasing the speed of the downstroke of the plunger which is operative regardless of the slant of the well bore where the pump is located, and which is equally effective throughout the stroke, without limit as to the length of the stroke.

The manner of accomplishing the foregoing objects as well as further objects and advantages will be made manifest in the following description taken in connection with the accompanying drawings in which

FIG. 1 is a diagrammatic vertical sectional view of a preferred embodiment of the pump of the invention and illustrates this during a downstroke of said pump.

FIG. 2 is a view similar to FIG. 1 and illustrates said pump during an upstroke of the latter.

FIG. 3 is a detailed horizontal sectional view taken on the line 3—3 of FIG. 1 and illustrating the cross sectional area of the sucker rod through which said pump is reciprocated.

FIG. 4 is a horizontal sectional view taken on the line 4—4 of FIG. 1 and illustrates the standing valve sub of the invention as well as showing the cross sectional area of the solid plunger actuating piston which connects the sucker rod to the plunger of the pump.

Referring specifically to the drawings, the invention is there shown as embodied in a deep well pump 10 which includes a cylindrical tubular barrel 11 the upper end of which is internally threaded and screws onto the lower threaded end 12 of a sub 13, the upper threaded end 14 of which screws into the internally threaded lower end of a production tubing string 15.

The sub 13 is provided with a relatively large-diameter

axial bore 16 and is also provided with a multiple of circumferentially spaced smaller bores 17 which are counter bored at their upper ends to provide for the installation therein of standing valves 18 which check a downward flow of fluid through the bores 17 but permit fluid to readily flow upwardly through bores 17 and through the valves 18 into a column of production fluid 19 which occupies tubing string 15 during the operation of the pump 10.

Extending downwardly from the top of the well through the production tubing string 15 is a sucker rod string 20 made up of serially connected individual sucker rods 25 each of which is approximately 90 feet in length and which has a uniform cross sectional area as shown in FIG. 3 throughout its length excepting for short enlargements at its opposite ends for coupling adjacent rods together. The lowermost rod 25 of the rod string 20 connects at its lower end with a rod connector 26 having an internally threaded receptacle 27. Slidable in and making a close fit with the large diameter bore 16 of the sub 13 is a plunger actuating piston 28 which is preferably solid but which may be of tubular construction provided no flow of fluid is permitted through this piston. The upper end of piston 28 is threaded and screws into receptacle 27 of rod connector 26. Formed integrally with the lower end of actuating piston 28 is the externally threaded head 29 of the cylindrical tubular body 30 of a travelling valve 31. The body 30 is internally threaded at its upper end and screws onto the head 29, this body also having lateral fluid passages 32 formed therein and having a bottom wall 33 which is centrally apertured to provide a valve seat 34. The valve 31 includes a metal ball 35 which normally rests on seat 34. The valve body 30 is formed integral with the upper end of a tubular pump plunger 40 having a heavy reinforcing band 41 at its upper end, valve body 30 being united with said band by a frusto-conical neck 42. A suction and compression chamber 43 is thus formed within the barrel 11 between the sub 13 and the plunger 40.

Operation

When the pump 10 is placed in operation in a deep well it is submerged in a body of well liquid so that this flows upwardly into the barrel 11 and is readily available to be pumped upwardly as production fluid when the pump plunger 40 is reciprocated through the actuating piston 28 by the sucker rod string 20. Each reciprocation includes an upstroke as illustrated in FIG. 2 and a downstroke as shown in FIG. 1. During the upstroke, production fluid trapped in suction-compression chamber 43 is compressed by the plunger 40 owing to the valve ball 35 of the travelling valve 31 dropping into its seat 34, and when the pressure of fluid in the chamber 43 exceeds that of the production fluid column 19 in the tubing string 15, the standing valves 18 open as shown in FIG. 2 and the production fluid under compression in the chamber 43 is expelled upwardly through said valves into the lower end of the production fluid column 19.

When the plunger 40 reaches the upper end of its upstroke and starts downwardly, owing to the sucker rod string 20 starting downward, the pressure in the pump chamber 43 falls far below the existing hydraulic pressure in the lower end of the production fluid column 19 in tubing string 15 which causes the standing valves 18 to immediately close thus producing a vacuum in pumping chamber 43. Further dowward movement of the plunger 40 and operating piston 28 sucks well fluid upwardly through the plunger 40 and valve 31, this fluid flowing outwardly through openings 32 into the pumping chamber 43. At the conclusion of the downstroke the pumping chamber 43 has thus taken on a fresh charge of well liquid, and, as the downward movement of the

plunger halts and its upward movement starts, the travelling valve 31 closes and during the upstroke which follows and which is illustrated in FIG. 2 said well liquid within pump chamber 43 is forced upwardly through the standing valves 18.

The pump 10 was concieved and designed with particular reference to its advantages when used in pumping a relatively highly viscous oil. The concept of this pump makes use of the relatively high hydrostatic pressure existing at the lower end of production fluid column 19 to give a very substantial assist to the forces normally acting to move the plunger of a deep well pump downwardly through its downstroke so as to overcome the retarding forces resisting this downward movement which are occasioned by the high viscosity of the oil. This assist is provided by the relatively large cross sectional area of the bore 16 and plunger actuating piston 28 as compared with the cross sectional area of the sucker rods 25 employed in making up the rod string 20.

The specific gravity of the fluid in the production column 19 varies in different wells and the depth of the pump in the well also varies, but a conservative value for the hydrostatic pressure at the bottom of the production fluid column in a well 5,000 feet deep is 1700 lbs. per sq. in. The pump 10 may be designed with a differential between the cross sectional areas of the piston 28 and the sucker rod 25 of from one to four square inches. Pump 10 can thus be designed to provide for a downward hydrostatic assist of from 1700 lbs. to 6800 lbs. applied axially directly to plunger 40 throughout its downstroke.

The great advantage this gives to the pump 10 when operating on high viscosity oils is that the above-mentioned assist for speeding up the downstroke of the pump is accomplished without the adding of any weights to the pump or encumbering the latter with springs. Furthermore the assist provided in the pump 10 is substantial, and controllable in the design of the pump to meet the particular conditions under which an individual pump is used. Furthermore, this assist operates uniformly on the plunger actuating piston 28 and is transmitted thereby to the plunger 40 throughout the stroke of the latter and it permits the pump to be designed with a stroke of any desired length so as to increase the production capacities of the pump while at the same time making available the above described assist throughout the downstroke of the pump.

Finally, it should be noted that the downward assist provided in pump 10 which speeds up the downstroke of the pump plunger thereof is not impaired in any way by the section of the well in which the pump is located being slanted out of vertical. Even if that section of the well were disposed horizontally the hydrostatic pressure existing at the lower end of the production fluid column 19 would continue to assist the suction stroke of the plunger 40 throughout the length of that stroke, regardless of the length of the latter.

As above noted, the drawings disclose the invention diagrammatically and only one form of the invention is shown, this being for illustrative purposes only. It is therefore to be understood that various changes and modifications may be made in the invention as shown and described herein without departing from the spirit of the invention or the scope of the appended claims.

The claims are:

1. In a deep well pump for pumping highly viscous oil, said pump being adapted to be located at the lower end of a string of production tubing and actuated by a sucker rod within said tubing, the combination of: a sub connected to and closing the lower end of said tubing to confine a column of production fluid therein, said sub having an axial bore of relatively large diameter compared to the diameter of said sucker rod; a plunger actuating piston closely fitting said bore and reciprocable therein; connector means connecting the upper end of said piston to the lower end of said sucker rod for repeatedly reciprocating said piston in said bore, each reciprocation including a suction stroke and a compression stroke; standing valve means provided in said sub permitting an upward flow of production fluid therethrough into said production fluid column but preventing a reverse flow of fluid therethrough; reciprocating pump means having a suction and compression chamber communicating with the lower end of said standing valve means for drawing production fluid from said well into said chamber on the suction stroke of said pump means and forcing fluid from said chamber upwardly through said standing valve means and into said production fluid column on the compression stroke of said pump means; and means for connecting said piston to said pump means to produce a suction stroke of the latter by each downstroke of said piston and a compression stroke of said pump means during each upstroke of said piston, said standing valve means remaining closed during the downstroke of said piston whereby a very substantial net downward hydrostatic pressure is imposed upon said piston by the fluid head of said production column, in addition to the weight of said sucker rod, thereby speeding up the downstroke of said piston and increasing the productive capacity of said pump means.

2. A combination as recited in claim 1 wherein said pump means includes a pump barrel secured to and extending downwardly from said sub; a plunger slidable in said barrel to form said suction and compression chamber in said barrel between said sub and said plunger, said plunger having a passage extending vertically therethrough and connecting upwardly with said chamber; a travelling valve checking downward fluid flow in said passage; and means for attaching the upper end of said plunger to the lower end of said piston.

3. A combination as recited in claim 2 wherein said plunger is tubular and said travelling valve is located at the upper end of said plunger.

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