Sept. 11, 1951 M. W. HAINES 2,567,513

WELL PUMPING SYSTEM

Filed July 2, 1945

FIG. 1.

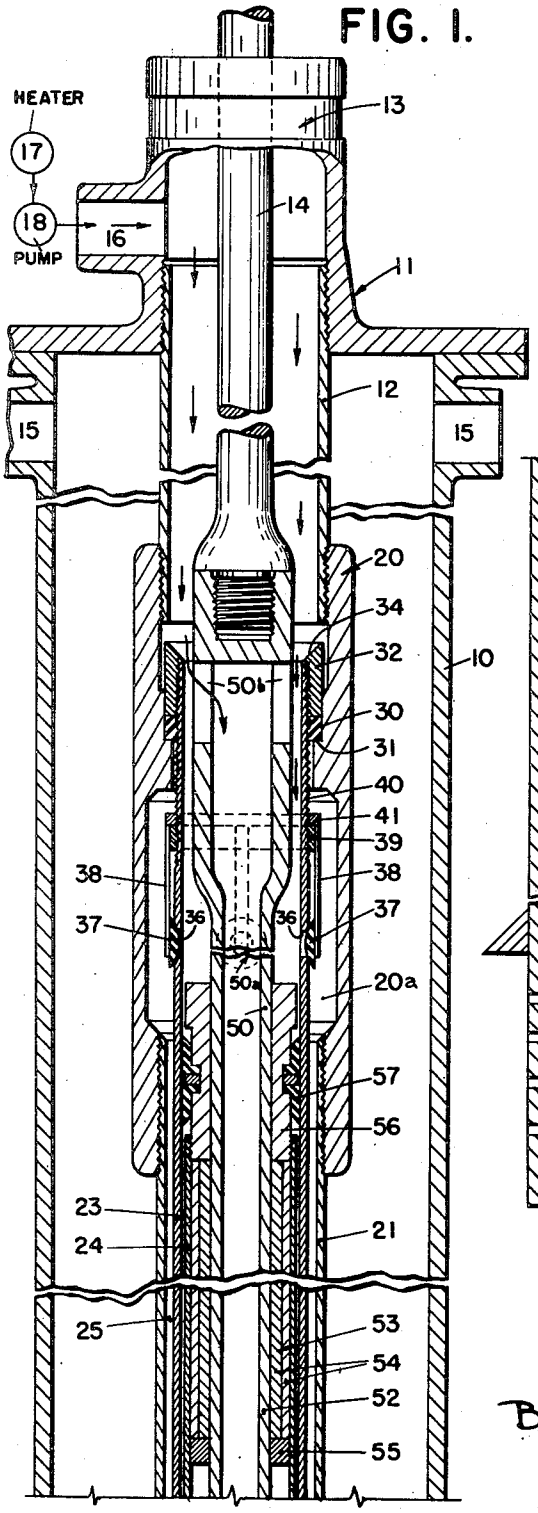


FIG. 3.

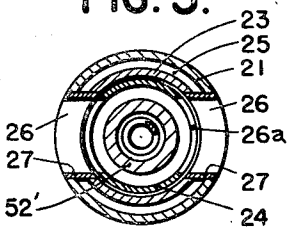
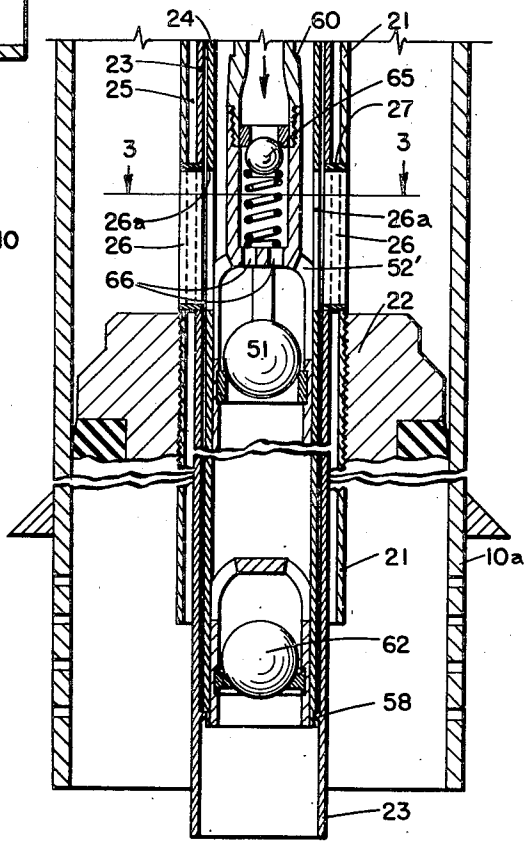


FIG. 2.



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WELL PUMPING SYSTEM

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3 Claims. (Cl. 103—1)

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This invention has reference to the pumping of deep wells by rod operated pumps. Its general object will be best understood from the following discussion and description.

In my copending application, Ser. No. 583,355, filed May 17, 1945, relating to the same general subject matter as that of this application, I have described a system and various forms of apparatus for enclosing the pump rod in a lubricant filled tube outside of which the column of well fluid is pumped to the surface. As there disclosed, the lubricating fluid may be pumped down the inner tube and discharged into the well to mix with the fluid being pumped; and the lubricating fluid may be of such quality, characteristic and/or temperature as to lighten the well fluid or reduce its viscosity. The general result is to make the rods more easily operable and to render the well fluid more easily movable, as well as to heat the well if the introduced fluid be heated.

The general purpose of the present invention, which is an improvement in certain aspects upon my original invention, is among other things to provide a system and a means whereby the fluid which is introduced into the well may more effectively mix with the well fluid to increase the fluidity of the well fluid and to increase the rate of flow into the well. In accordance with my present invention, that increase in fluidity of the well fluid takes place at the zone of inflow of the fluid into the well, and at the fluid producing strata, and may be achieved by using an introduced fluid, either gaseous or liquid, which increases the fluidity of the well fluid either by admixture or by transferring heat or by both. In a typical and illustrative system in accordance with my invention, I may introduce to the well a fluid which is lighter or less viscous than the well fluid itself, and also heat the introduced fluid, so that by admixture with the well fluid (heavy petroleum for instance) the inward flow through and from the producing strata is increased, and at the same time the pumping column is rendered more easily pumpable.

In my invention of my previous application the introduced fluid is specifically delivered to the well fluid in the pumping column. In my present invention the introduced fluid is delivered to the well fluid at the perforated liner and at the formation from which the fluid flows into the well, and at a point below the pump. The result is that, in addition to accomplishing all the desirable results of my former invention (easing both the operation of the pump rods and the

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lifting of the pumping column) my present invention induces more free flow of well fluid from the formation into the well—either by admixture, dilution or heating, to increase the freedom and fluidity of flow of the well fluid into and through the pump, and also provides means for controlling the sand in the well fluid. By increasing the fluidity of the well fluid below the pump, sand settlement may be controllably induced below the pump to limit the percentage of sand taken by the pump. And at the same time, by reducing the viscosity of the fluid flowing from the formation into the well, less sand is carried into the well even though the fluid flow is increased.

In my original invention as described in said copending application, the fluid which is introduced to the well is preferably a lubricating fluid introduced through a tube or pipe immediately surrounding the pump rods and serving to lubricate the pump rod, and also to fluidize or lighten the pumping column. The introduced fluid may be put down either through a special inner tube located inside the ordinary tubing, and the pumping column may be pumped up through the tubing, or the tubing or a pipe which takes its place may serve for introduction of the fluid and the well fluid may be pumped up in the space external of the tubing and immediately inside the well pipe or casing. The same things are true of my present invention, but I prefer here to show, as illustrative of the invention, the pumping of the well fluid upwardly in the annular space between the well pipe or casing and the tubing or pipe which takes its place.

Also in my copending application, and herein, I speak of the introduced fluid as a lubricating fluid; and in many installations the introduced fluid may be a lubricating fluid in the positive sense of the word—acting as a lubricant for the reciprocating pump rods. However, in some cases the so-called lubricating fluid may only be such in a comparative or negative sense, in that its presence around the pump rods excludes the heavy viscous well fluid from contact with the rods; the introduced fluid being less viscous either because it has that quality at the same temperature as the well fluid, or because it is heated.

The following detailed description of a preferred and illustrative system and apparatus, but without implied limitation, will give a more full idea of my present invention. Reference for the purpose of the description is had to the accompanying drawings in which:

Fig. 1 is a vertical longitudinal section showing the upper part of a preferred and illustrative form of apparatus applied to a well;

Fig. 2 is a similar view of the lower part of the apparatus; and

Fig. 3 is a detail section taken on line 3—3 of Fig. 2.

In the drawings numeral 10 designates a well casing or well pipe with a perforated lower section 10a at the producing strata from which oil enters the well pipe through the perforations.

The well pipe is shown as being equipped with a cap 11 at its upper end at the ground surface. The tubing 12, or other pipe which takes its place, hangs from cap 11; and the cap is shown equipped with a packing gland 13 through which pump rod 14 passes. Outlets for the pumping column from the well pipe are shown at 15, and an inlet 16 is shown for the introduced fluid, which may be heated by a heater indicated at 17 and put under pressure by a pump indicated at 18. As has been mentioned, the introduced fluid is, in this illustrative form of my invention, moved down into the well through the tubing or the pipe which takes it place.

At some point preferably reasonably close to the pump, the tubing is provided with a special sleeve fitting which is designated generally by the numeral 20, and a tubing extension 21 extends on downwardly from fitting 20 and carries a packer 22 of any suitable type at its lower end. The function of the packer is to seal off the annular space between the tubing and the well pipe at a point above the pipe perforations, so that the annular space above the packer may take the pumping column. Broadly speaking, tubing extension 21 may be viewed as a part of the tubing. A purpose of providing the special sleeve fitting at 20 is to facilitate structure for the bypassing of the introduced fluid downwardly past packer 22, and also to facilitate a design and arrangement which will enable all of the operating parts of the pump to be pulled by pulling the pump rod.

Inside fitting 20 and tubing extension 21, and spaced annularly therefrom, and extending on downwardly below packer 22 I provide a pump carrying tube 23 which takes the pump barrel or liner 24 and which, with the tubing extension 21, forms the annular passage 25 which extends down from the interior chamber 20a of fitting 20 and through the packer 22. This downward passage for the introduced fluid bypasses the openings 26 through which the pumping column reaches the annular space outside the tubing. Those openings 26 are formed, through tube 23 and across passage 25 and through tubing 21, by inserted and preferably welded liners 27. Tubing extension 21 may have its lower end either at packer 22 or it may extend on down for any desired distance below the packer, as indicated in the drawing, so that the introduced fluid may be delivered either directly under the packer or at any desired elevation below the packer; but preferably in any case above the lower end of tube 23 which forms the intake for well fluid to the pump.

Tube 23 and tubing extension 21 being relatively longitudinally immovable because of the passage bridge at 27, and the upper end of tubing extension 21 being threaded into fitting 20, a fluid-tight joint between tube 23 and fitting 20 is provided by a packing ring 30 which is set down on an internal fitting shoulder 31 by a follower ring 32 threaded onto the upper end of

tube 23. The upper ends of 23 and 32 are inwardly beveled at 34 to guide the pump assembly into tube 23 when that assembly is lowered.

The purpose of the packing at 30 is to prevent the fluid which is introduced through tubing 12 from reaching annular passage 25 directly around tube 23 and through fitting 20. As will be quite obvious, the introduced fluid could reach passage 25 in that manner by the mere omission of packer 30 and packing shoulder 31, but it is preferred to pass the introduced fluid downwardly through the upper end of tube 23 and then outwardly through the wall of that tube through valve controlled openings 36. These openings are conveniently controlled by valves 37 mounted on the lower ends of spring arms 38 whose upper ends are conveniently mounted on a ring 39 which is threaded upon threads 40 on tube 23 and set by a lock ring 41. Valves 37 open outwardly under a small differential pressure. Their purpose is to prevent well fluid rising through passage 25 and upwardly into tubing 12 if at any time pressure of the well fluid is great enough to rise in the tubing or is substantially greater than pressure on the introduced fluid in the tubing.

Pump rod 14 is provided at its lower end with a hollow rod extension 50. For the purpose of contracting the drawing in length, the upper end of hollow rod extension 50 is shown in Fig. 1 at about the level of the upper end of tube 23—in such a relative position as it ordinarily will occupy at the lower end of the pump stroke. For the same reasons, the working valve 51 of the pump is shown in Fig. 2 in about the position it will occupy at the upper end of the pump stroke. The break shown at 50a in Fig. 1 in the hollow rod extension 50 is intended to indicate that the upper part of 50 would normally be above the position shown in the drawing and that the shank portion 52 of hollow rod 50 is long enough to pass through the metallic packing unit 53, which seals the space between pump liner 24 and the hollow rod, and long enough to accommodate the pumping stroke. Metallic packing unit 53 is shown as made up of concentric segmental sleeves 54 confined longitudinally between a lower shoulder ring 55 which is mounted on the inside of pump liner 24, and an upper fitting 56 which is screw-threaded into the upper end of pump liner 24. This upper fitting 56 also carries the sealing element or packing 57 which seals off the annular passage which would otherwise be left open between pump liner 24 and inner tube 23. The pump liner preferably fits rather freely in tube 23 and at its lower end has the usual seat 58 on tube 23.

The central or shank portion 52 of hollow rod 50 is preferably somewhat smaller than its upper and lower ends, and an upwardly facing shoulder at 60 may be provided to engage the under face of shoulder ring 55 when the rods are pulled upwardly, to pull pump liner 24 and all of its attached parts along with the pump rod.

Except for the desirability of being able to pull the whole pump mechanism with the pump rods, the pump carrying tube 23 might just as well be the pump barrel; that is, 23 and barrel 24 may be looked at as a single member. Further, either the tube 23 or 21, or both of them, may be viewed as downward continuations of the tubing 12; the assembly of the two tubes providing the pump carrying tube open at its lower end, and the passage from the tubing downwardly through the packer.

Fluid which is introduced to the well through tube 12 passes downwardly and into the upper end of tube 23, and thence outwardly through valve controlled openings 36 to the exterior of tube 23 into chamber 20a, and into the annular passage 25 through which it flows downwardly through packer 22 and is discharged into the well at any desired point below that packer. That fluid, introduced at any such point below the packer, intermingles with the body of well fluid in the well casing below the packer and in immediate proximity to the perforations and producing strata, and has the function of lightening and reducing the viscosity of that well fluid either because of mixing with well fluid, or because of transferring heat to it, or both. The introduced fluid may preferably be one which is lighter and less viscous than the well fluid, and miscible with the well fluid in all proportions preferably by forming a solution with it. On the other hand it may be merely physically mixable with the well fluid. The introduced fluid may be either a gas or a liquid, and it may perform its function of lightening the well fluid by mere admixture or solution therewith, the introduced fluid being of lighter and less viscous fluid than the well fluid. On the other hand, the introduced fluid may be heated, and perform its function of lowering the viscosity of the well fluid by heating it; or the introduced fluid may perform the function in both the prescribed manners. In any case, the introduced fluid, mixing with the body of well fluid below packer 22 and in proximity to the producing strata, reduces the viscosity of the oil directly at the producing strata, and, by diffusion or by heat conduction, reduces the viscosity of the well fluid in the strata itself and thus increases flow into the well.

The lightened and less viscous admixture, or the heated and thus less viscous well fluid will be picked up by the pump from the body of fluid below the packer, pumped upwardly in pump liner 24 and out through openings 26a through the liner wall which register with the openings 26 previously described. The pumping column thence passes up to the surface through the annular space between the tubing and the well pipe.

Provision may also preferably be made for introducing the introduced fluid, under certain circumstances at least, or in predetermined proportions, directly to the pumping column above packer 22. For that purpose the rod extension 50 is made hollow and has ports 50b leading through its wall at its upper end. The introduced fluid may thus also pass down through the hollow rod to a point below the packing unit 53 where its exit into the pumping column may be controlled by a suitable valvular means, such as the upwardly seating spring loaded valve 65 in retaining member 52'. If valve 65 is open the introduced fluid may pass downwardly past it and then out through openings 66 into the space immediately above pump valve 51 and thus pass into the pumping column. The spring loading on valve 65 may be selected to predetermine the pressure at which the introduced fluid will be directly fed into the pumping column. The pressure at which valve 65 opens may be set high enough that, in normal operation, all of the introduced fluid will be passed down through passage 25 into the well below packer 22, valve 65 only opening under conditions which may cause excessive pressure on the introduced fluid.

On the other hand, by appropriately restricting the passage for the introduced fluid through annular passage 25 (as for instance by restricting the size of ports 36) and by then appropriately selecting the spring loading of valve 65, the system may be normally operated to deliver a selected volume of introduced fluid to the well below the packer against the pressure of the well fluid, and also a selected proportionate volume into the pumping column above the packer against the pumping column pressure. That proportioning of delivery of the introduced fluid is most feasible when the well fluid pressure is fairly high compared with the pumping column pressure. In any such case the pressure on the introduced fluid must be greater than the higher of those two pressures—usually the pumping column pressure.

However, in the operation of the system in the usual circumstances where the pumping column pressure is much greater than the well pressure, it is contemplated that the introduced fluid will only be normally put under a pressure sufficient to introduce it to the well below the packer against the well pressure. And the simple hydrostatic column pressure of the fluid in the tubing will in most if not all cases be sufficient for that purpose, so that no additional pressure need be raised by the pump 18. The spring loading of valve 65 will ordinarily be set so as to prevent fluid passing out into the pumping column under the hydrostatic column pressure (a slight loading is sufficient). The rate of delivery of the introduced fluid into the well below the packer will then be governed by the rate at which the fluid is introduced at the top of the tubing, the hydrostatic column in the tubing adjusting itself to the well pressure. Valve 62 is associated with and has functional relation to the system, in the same manner as described in my copending application.

I claim:

1. Apparatus for pumping viscous liquids from wells comprising the combination of an outer pipe extending from the surface down into the well, an inner tube extending from the surface downwardly within the outer pipe and in spaced relation thereto, a pump barrel carried by the lower end of the inner tube, an extension tube surrounding the pump barrel and annularly spaced therefrom and forming a downward passage in continuation of the inner tube and discharging into the well at its lower end, a seal between said extension tube and the outer pipe to seal off the space into which said tube discharges, a reciprocable pump plunger in the pump barrel, a plunger operating rod extending down from the surface through the inner tube, means forming a discharge passage from the pump barrel into the annular space in the outer pipe above the seal, and means for introducing fluid into the upper end of the inner tube.

2. Apparatus for pumping liquids from wells, comprising the combination of an outer pipe extending from the surface down into the well, an inner tube extending from the surface downwardly within the outer pipe and in spaced relation thereto, a pump carrying tube carried by the inner tube at its lower end, a reciprocable pump plunger in the pump carrying tube, a plunger operating rod extending down from the surface through the inner tube, a tube surrounding the pump carrying tube and annularly spaced therefrom and forming therein an annular passage which communicates at its upper end with the inner tube, a seal closing the annular space be-

tween the last mentioned tube and the outer pipe, means forming an outlet passage for the pump leading from the interior of the pump carrying tube to the annular space above the seal, and means for introducing fluid into the upper end of the inner tube.

3. Apparatus for pumping viscous liquids from wells comprising the combination of an outer pipe extending from the surface down into the well, an inner tube extending from the surface downwardly within the outer pipe and in spaced relation thereto, a pump barrel carried by the lower end of the inner tube, an extension tube surrounding the pump barrel and annularly spaced therefrom and forming a downward passage in continuation of the inner tube and discharging into the well at its lower end and constantly open for passage of fluid from the inner tube to the well at said lower end of the extension tube under a differential in the pressures in the tube and in the well at said lower end of the extension tube, a seal between said extension tube and the outer pipe to seal off the space into which said tube discharges, a reciprocable pump plunger in the pump barrel, a plunger operating rod extending down from the surface through the inner tube, means forming a discharge passage from the pump barrel into the annular space in the outer pipe above the seal, and means for maintaining a body of relatively non-viscous fluid in the inner tube around the pump rod at a pressure which at least substantially balances the pressure of the well fluid at the lower end of the extension tube.

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