Jan. 16, 1962 J. R. CREED 3,016,833

APPARATUS FOR AND METHOD OF PRODUCING HEAVY OIL

Filed May 29, 1959

2 Sheets-Sheet 1

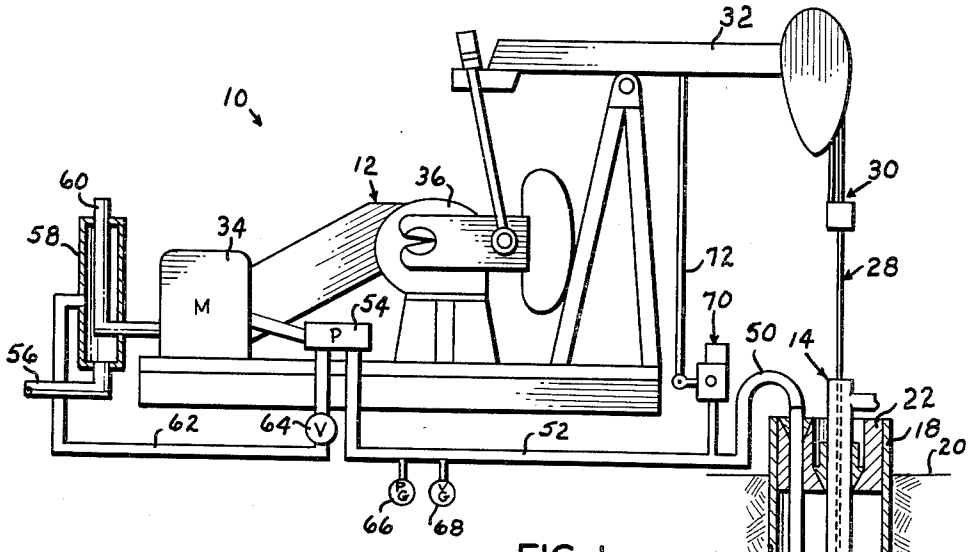
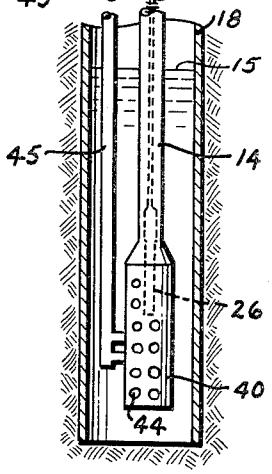


FIG. 1



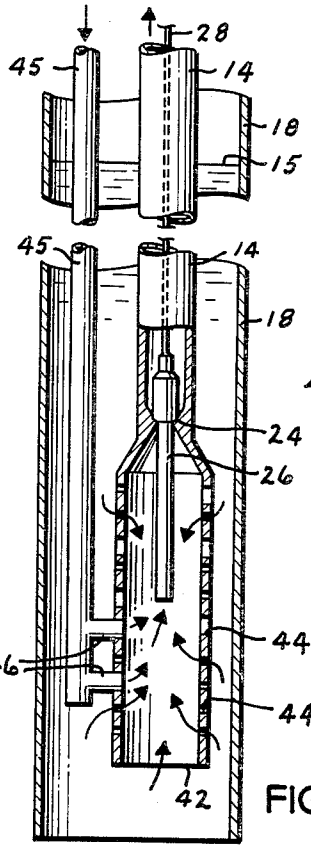


FIG. 2

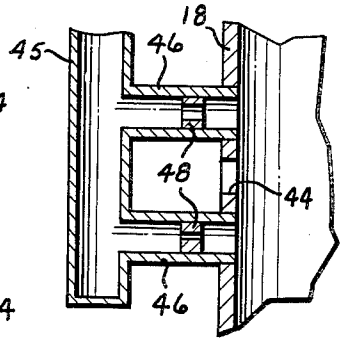


FIG. 3

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APPARATUS FOR AND METHOD OF PRODUCING HEAVY OIL

Filed May 29, 1959 2 Sheets-Sheet 2

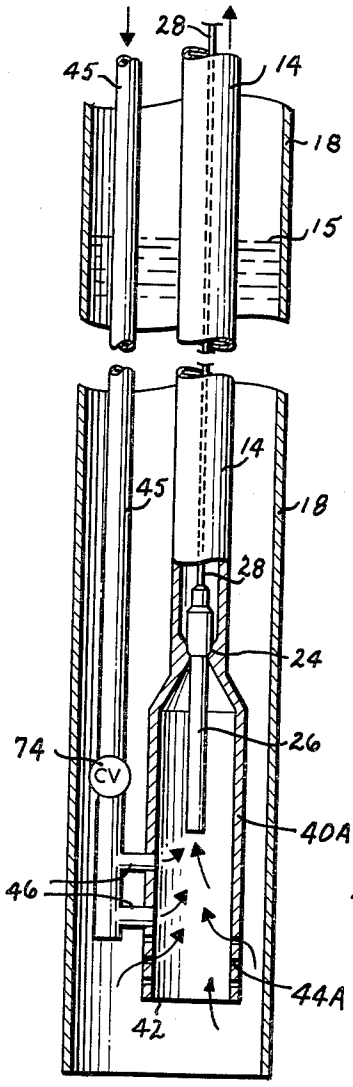


FIG. 4

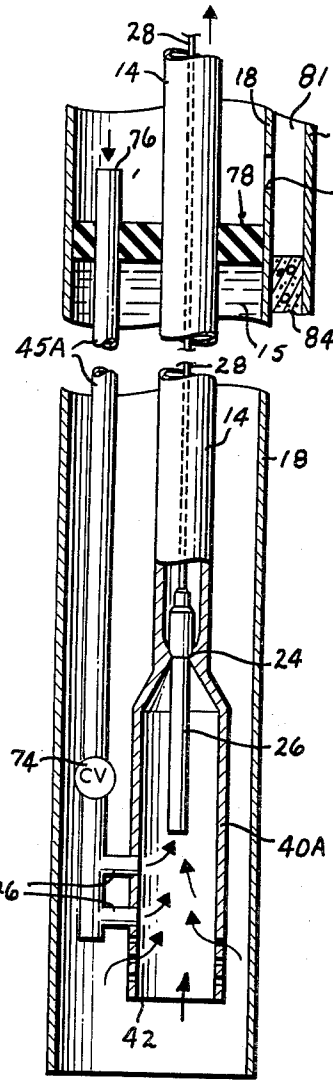


FIG. 5

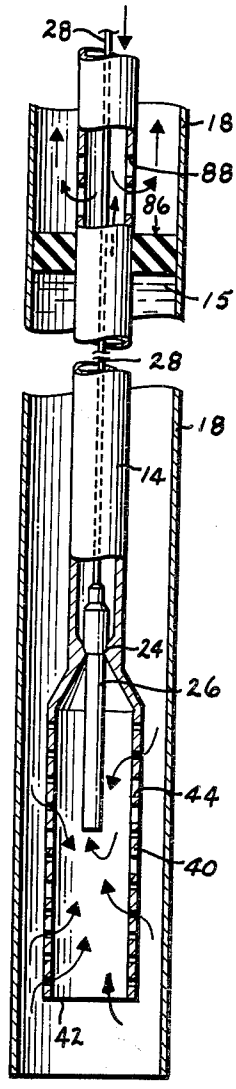


FIG. 6

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3,016,833
APPARATUS FOR AND METHOD OF PRODUCING HEAVY OIL

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4 Claims. (Cl. 103—1)

The present invention relates to the oil industry and more particularly to recovery of heavy viscous oil from individual wells.

It is well understood by those skilled in the production of oil that some types of oil, such as heavy asphaltic oils, are too thick to be pumped by conventional pumping equipment. Such oils, however, can be pumped when heated or diluted to a fluid state.

It is, therefore, the principal object of the instant invention to provide an apparatus for diluting heavy viscous oils, while in the individual well, for pumping the oil to the surface of the earth.

Another important object is to provide an apparatus and method of controlling the viscosity of oil within a well so that production of the heavy oil may be continuous as long as the supply from the oil producing zone is constant.

Another object is to provide an apparatus and method which will increase the volume of production of heavy oil to an amount which will make operation of the well profitable when compared with the former volume of production.

Another object is to provide an apparatus which will heat and properly mix a diluent oil and intermingle the latter with heavy oils contained within the bore of a drilled well.

Still another object is to provide an apparatus and method for producing heavy viscous oil from a drilled well which contains sand mixed with the heavy oil to such an extent that production of heavy oil, under conventional methods, quickly wears out the pump and renders such production by conventional methods unprofitable.

Other objects are to provide an apparatus and method for producing heavy oil from well bores which include a comparatively wide range of gravity of the diluent used, variation of volume of diluent oil with respect to the heavy oil produced, variation between vacuum and pressure for injecting the diluent into the well and rendering the pulling of rods and tubing more easily accomplished by eliminating the tendency of the heavy oil to cling to the tubing and rods.

The present invention accomplishes these and other objects by providing a downwardly open gas anchor which is axially connected to the depending end of a pumping string positioned within the well bore below the fluid level. A conventional pumping unit means is connected with the rods within the tubing string for operating the bottom hole pump carried therein. A second tubing string, installed in the well, is connected at its lower end portion to the gas anchor, intermediate its ends, for fluid communication therebetween. Diluent oil is injected into the anchor from a source of supply at the surface of the earth through the second tubing string.

Other objects will be apparent from the following description when taken in conjunction with the accompanying two sheets of drawings, wherein:

FIGURE 1 is an elevational view, partly in cross section, diagrammatically illustrating the apparatus in operative position;

FIGURE 2 is a fragmentary, vertical, cross-sectional view, partly in elevation, of the lower end portion of the tubing strings within a well bore;

FIGURE 3 is a fragmentary, vertical, cross-sectional view illustrating the manner of connecting the secondary to the primary string of tubing; and

FIGURES 4, 5 and 6, are views similar to FIG. 2, illustrating alternate arrangements of the oil diluting and pumping apparatus.

Like characters of reference designate like parts in those figures of the drawings in which they occur.

In the drawings:

The reference numeral 10 indicates the apparatus, as a whole, which includes a conventional oil well pumping mechanism, indicated generally by the numeral 12 and operatively connected to a string of primary or pumping tubing 14 containing a bottom hole fluid oil pumping means 26 and installed in a drilled well 16. The well 16 is illustrated in simplified form having a casing 18 extending from adjacent the surface of the earth 20 downward toward the bottom of the well as is conventional. The upper end portion of the casing supports a slip equipped tubing head 22 which in turn supports the conventional string of tubing 14. The lower end portion of the tubing 14 is positioned below the fluid level 15 of the oil therein and is provided with a conventional hold down shoe 24 for receiving the conventional bottom-hole top-hold-down type oil well pump 26 having a reciprocating plunger. A string of rods 28 is connected with the pump plunger and the bridle 30 carried by the pumping unit walking beam 32. The pumping unit 12 includes an engine 34 operatively connected with the walking beam 32 through a counterbalanced gear train 36 to impart reciprocating movement to the sucker rods and pump plunger. The above described pumping equipment is conventional and forms no part of the instant invention other than to set forth a description of a typical oil well being produced by pumping equipment which is used in combination with the hereinafter described parts and means.

A gas anchor 40 having a diameter substantially greater than that of the tubing 14 is axially connected to the depending end of the latter around the pump 26. The gas anchor 40 preferably has a depending open end 42 and is further provided, throughout its length, with a plurality of ports or apertures 44 through its wall. The apertures 44 are preferably of such size that the oil 15 may flow therethrough and into the anchor.

A secondary string of tubing 45 is installed within the bore of the casing 16 simultaneously with the pumping string 14. The lower end portion of the tubing 45 is connected to the gas anchor 40 by a pair of horizontal tubes 46 for fluid communication between the tubing 45 and bore of the gas anchor. The tubes 46 are each provided with orifices 48 of a selected size or, if desired, swedges, not shown, may be used in connecting the two tubing strings. Adjacent the surface of the earth the tubing 45 is connected with a length of flexible hose 50, or the like, which is in turn connected with one end of a horizontal line 52. The opposite end of the line 52 is connected with a pump 54 driven by the engine 34.

The line 56 is connected at one end with a tank or reservoir, not shown, containing a supply of diluent fluid and is connected at its opposite end with the lowermost end of a cylindrical-like housing or shield 58 which surrounds a length of the vertically disposed portion of the engine exhaust 60. The shield 58 thus forms a heater for raising the temperature of diluent fluid conveyed by the line 56. One end of a line 62 is connected to the shield 58, at a point remote from the connection of the line 56, and is connected at its opposite end with the pump 54, through a valve 64, for conveying heated diluent fluid to the pump. A pressure gauge 66 and a vacuum gauge 68 are each connected to the line 52.

A chemical injector pump 70, which is conventional, is connected with the line 52 for adding a selected quantity of crude oil treating medium to the diluent fluid. The chemical pump 70 is driven in a conventional manner by a rod 72 connected with the walking beam 32.

Operation

The apparatus is installed in a well as disclosed hereinabove and as diagrammatically illustrated in FIG. 1.

Diluent fluid flows by gravity to the pump 54 from the source of supply, not shown, through the lines 56 and 62. The pump moves the diluent through the line 52 and tubing 45 to the gas anchor 40 where the diluent is intermingled with the asphaltic or heavy oid and reduces the viscosity of the latter. I have found that the range of gravity of diluent oil may vary from 20 percent to 40 percent and the ratio of the volume of diluent fluid to the heavy oil may be varied from 5 percent to 40 percent. The state of the oil, or its viscosity, determines the pressure required for injecting the diluent into the oil in and surrounding the gas anchor which may vary from 2,500 pounds per square inch, at the surface of the earth, to a vacuum pull of 25 inches. This variation is occasioned by particularly heavy oil which necessitates the above pressure in order to force the diluent into such oil adjacent the bottom of the well, and after starting such injection and starting the pumping apparatus 12 pumping the diluted oil, the action of the pump 26 in removing the diluted heavy oil from the well bore and casing, aids the diluting process and results in free flowing movement of the diluent fluid through the tubing 45 which, as the pump 26 continues to pump out the diluted oil, results in a vacuum pull on the diluent line 52; thus it may be seen that after starting the production of diluted heavy oil from a well, a point of balance may be achieved wherein the heavy oil flowing toward the gas anchor 40 and being removed by the pump 26 uses only a necessary portion of the diluent fluid for reducing the viscosity of the heavy oil so that the pump 26 can handle the oil. This arrangement of injecting the diluent oil into a well will operate in this manner in a 4,000 foot well wherein the level of the oil 15 in the well bore varies from 20 feet to 4,000 feet in depth. The range of percentages of sand or water contained by the heavy oil does not affect the production of the heavy oil in that the sand produced from the oil bearing formation and carried by the oil 15 may vary from zero to 70 percent and the range of salt water contained by the oil 15 may vary from zero to 80 percent. Obviously heavy oil having a relatively high percentage of water reduces the amount of diluent fluid necessary to render the heavy oil to a fluid pumping stage. Injection of oil treating fluid or chemicals into the diluent line 52 before the diluent fluid enters the heavy oil in the well aids in breaking down the oil-water emulsion formed by the passage of the heavy oil through the pump and permits easier separation of the oil and water in storage tanks, not shown, at the surface of the earth. Thus in many wells the oil so pretreated renders the produced oil capable of being transported to its destination by a truck or pipe line as desired. The cost of treating the produced oil is reduced by approximately 50 percent when producing heavy viscous oils from wells containing up to 70 percent water. Another feature of the operation of this method and apparatus of producing heavy oil is the ability to inject diluent fluid into the gas anchor and surrounding oil before pulling both strings of tubing to service the pump or the tubing thus lowering the viscosity of the heavy oil which causes the latter to loose some of its sticky or adhesive characteristics and thus fall free, by gravity, and remain in the well as the tubing is pulled.

An alternate form of the gas anchor is illustrated in FIG. 4 and indicated by the numeral 40A. The configuration of this gas anchor is identical with respect to the anchor 40 and is provided with openings or apertures 44A which are disposed below the lowermost one of the tubes 46. A check valve 74 is installed in the tubing string 45. Thus the heavy oil 15 enters the gas anchor 40A through its open end and the apertures 44A and mixes with the diluent entering the anchor from the tubing 45. The check valve 74 prevents any reverse flow of the mixed oil and diluent into the tubing 45 which might be occasioned by fill-up of the well bore when the pumping unit is idle.

FIG. 5 illustrates an installation of the pumping tubing 14, pump 26 and gas anchor 40A but is further characterized by only a relatively short or stub length of the secondary tubing string 45A. The tubing string 45A is preferably of a length which will permit the pumping string 14 to be positioned at the selected depth within the well bore and wherein the top open end 76 of the tubing 45A will be disposed above the level of the oil 15. A packer 78 is carried by the tubing strings 14 and 45A and is "set" in contact with the bore of the casing 18 adjacent the level of the oil 15 to form a fluid tight seal between the peripheries of the tubing strings and the casing. This permits elimination of the greater portion of the secondary string of tubing 45 wherein the diluent fluid medium is placed within the casing 18 and flows by gravity into the open end 76 of the tubing string 45A for mixing with and diluting the heavy oil within and surrounding the gas anchor 40A. If desired, an opening or port 80 may be formed in the wall of the casing 18 above the packer 78 and the diluent fluid may then be placed within the annular space 81 between the casing 18 and its surrounding casing 82 which is normally cemented with the casing 18 as at 84.

FIG. 6 illustrates another arrangement which eliminates the secondary tubing string 45 and wherein a packer 86 carried by the tubing string 14 bonds the pumping string to the casing at a point above the fluid level in the well. This arrangement is particularly effective in wells wherein the heavy oil is capable of being picked up by the pump and lifted to at least above the position of the packer 86, and where it is desired that the viscosity of the heavy oil may be lowered further for pumping or movement to storage areas. The tubing 14 is provided with a plurality of apertures 88 through its wall above the position of the packer 86. Diluent fluid is inserted into the bore of the tubing 14 at the surface of the earth. Thus the diluent contacts the pumped oil and intermingles with the latter, diluting the same, and flows out of the tubing through the apertures 88 into the annular space within the casing around the tubing. Continued pumping of the oil 15 and injection of diluent fluid fills the casing and is conducted from the upper end portion of the latter in a conventional manner.

Obviously the invention is susceptible to some change or alteration without defeating its practicability, and I therefore do not wish to be confined to the preferred embodiment shown in the drawings and described herein, further than I am limited by the scope of the appended claims.

I claim:

1. An apparatus for pumping viscid oil from individual oil wells in an oil producing area, comprising: a primary string of tubing adapted to be run into the oil well and extend from the surface of the earth to a point below the oil level in the well; a depending downwardly open elongated gas anchor substantially greater in horizontal cross-sectional area than said primary string of tubing axially secured to the lowermost end of said primary string of tubing string, said gas anchor having a series of vertically spaced ports in the lower end portion of its wall and having an imperforate wall portion extending thereabove; an oil well pump having a reciprocating plunger carried by the lower end portion of said primary string of tubing; a string of sucker rods connected with the plunger of said pump and extending to the surface of the earth; oil well power pumping means connected with the upper end portion of said sucker rods for imparting reciprocating movement to said sucker rods; a secondary string of tubing adapted to extend from the surface of the earth downward to and be connected with said gas anchor adjacent the lower limit of its imperforate wall portion for con-

veying a diluent fluid from a source of supply to the oil within said gas anchor; and means regulating the flow of diluent fluid through said secondary tubing string.

2. An apparatus for pumping viscid oil from individual oil wells in an oil producing area, comprising: a primary string of tubing adapted to be run into the oil well and extend from the surface of the earth to a point below the oil level in the well; an elongated gas anchor substantially greater in horizontal cross-sectional area than said primary string of tubing axially connected with the lowermost end of said primary tubing string, said gas anchor having a series of vertically spaced ports in the lower end portion of its wall and having an imperforate upper wall portion; oil pumping means installed in said primary string of tubing; oil well power pumping mechanism connected with said oil pumping means; a secondary string of tubing extending from the surface of the earth into the well and connected at its lowermost end portion with said gas anchor adjacent the lower limit of its imperforate wall portion for injecting a diluent fluid from a source of supply into said gas anchor; and means regulating the rate of injection of the diluent fluid into said gas anchor.

3. An apparatus for pumping viscid oil from an oil well in an oil producing area, said oil well having a string of casing extending from the surface of the earth to the oil producing zone, comprising: a primary string of tubing of smaller diameter than said casing and extending from the surface of the earth downward below the oil level within said casing; an elongated gas anchor axially connected with the lowermost end of said primary tubing string in depending relation, the diameter of said gas anchor being substantially greater than the diameter of said primary tubing and less than the diameter of said casing, said gas anchor having an imperforate upper wall area and a foraminated lower wall area; sucker rod and pump means installed within said primary tubing string; oil well pumping power means connected with said sucker rod and pump means for progressively moving fluid oil out of said gas anchor; and a secondary string of tubing, of less diameter than said primary string of tubing, extending from the surface of the earth downward within said casing and connected with said gas anchor, at the juncture of the imperforate and foraminated wall areas, for

injecting a diluent fluid from a source of supply into the viscid oil entering said gas anchor and reducing the viscosity of the heavy oil to a pumpable fluid state.

4. An apparatus for pumping viscid oil from individual oil wells in an oil producing area, comprising: a primary string of tubing adapted to be run into the oil well and extend from the surface of the earth to a point below the oil level in the well; an elongated gas anchor, substantially greater in horizontal cross-sectional area than said primary string of tubing, axially connected with the lowermost end of said primary tubing string, said gas anchor having a series of vertically spaced ports in its wall adjacent its lower end defining an imperforate wall portion extending upwardly thereabove; oil pumping means installed in said primary string of tubing; oil well power pumping mechanism connected with said oil pumping means; a secondary string of tubing extending from the surface of the earth into the well bore and connected at its lowermost end portion with said gas anchor adjacent the lower limit of its imperforate wall portion for injecting a diluent fluid from a source of supply into said gas anchor; and pump and valve means connected with said secondary string of tubing at the surface of the earth regulating the rate of injection of the diluent fluid into said gas anchor in direct proportion to the hydrostatic pressure of the viscid oil within said gas anchor and the rate of removal of diluted oil therefrom by said oil pumping means.

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