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CONTROL OF PARAFFIN DEPOSITION

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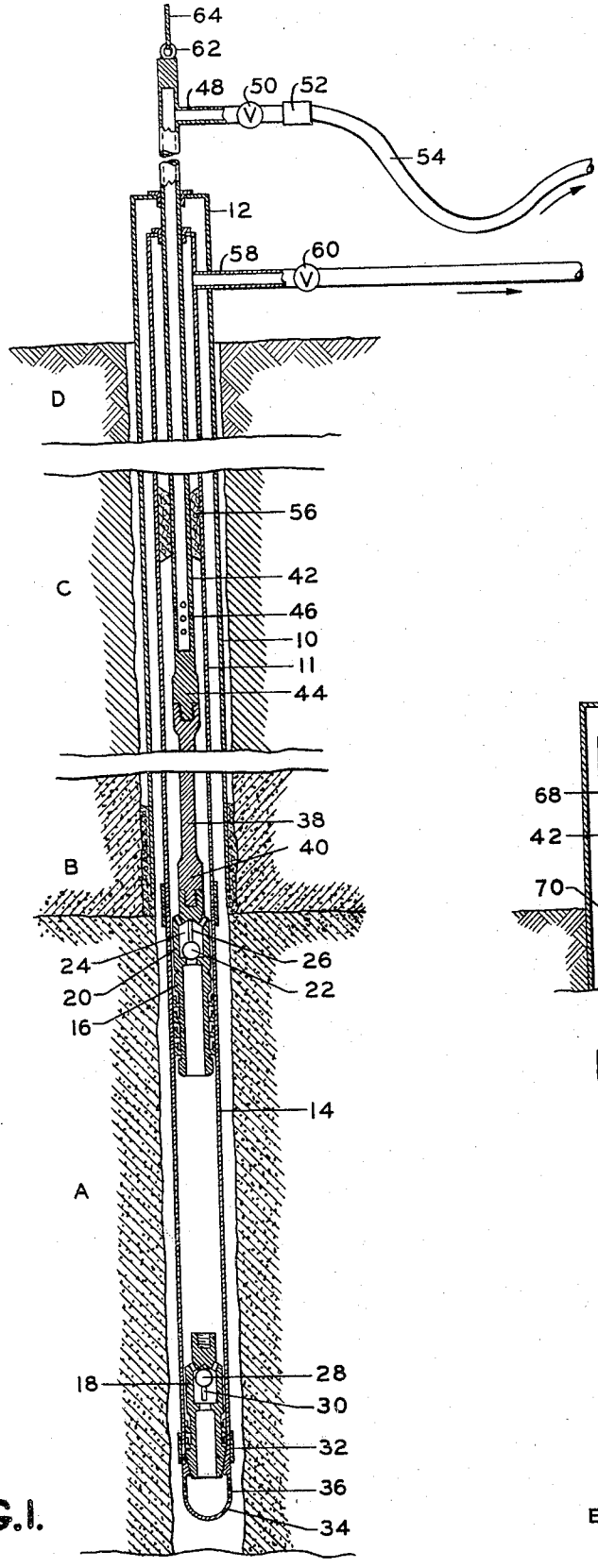

FIG. I.

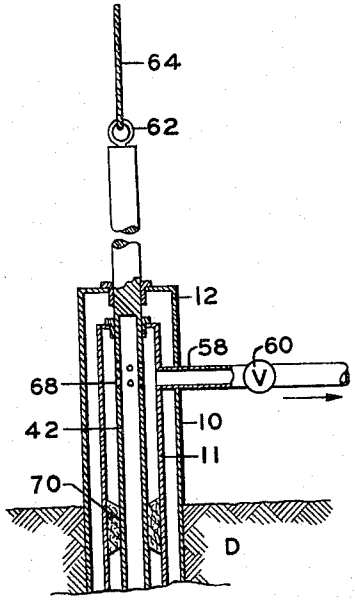

FIG. 2.

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CONTROL OF PARAFFIN DEPOSITION

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6 Claims. (Cl. 103—1)

This invention relates to a method for reducing or preventing paraffin deposition in a well pumping a crude oil tending to deposit paraffin. The invention also relates to well equipment suitable for carrying out the method.

The equipment usually employed in a well from which crude oil is being pumped comprises a casing, a flow tubing, and a pump disposed in the region of the producing formation. The pump, which may be any one of a number of different types, is actuated by a solid sucker rod which is subjected to vertical reciprocating motion by means of a pumping unit. The sucker rod is disposed in the flow tubing and the crude oil is forced to flow up the tubing around the sucker rod to the surface.

In many pumping wells paraffin deposition presents an important problem. This paraffin is usually a mixed material comprising wax and impurities precipitating from the oil during its flow from the formation to the surface. In many cases paraffin does not deposit throughout the entire depth of the well but begins to deposit at some point between the formation and the surface. For example, in the wells in one field paraffin began to deposit at distances varying from 300 to 1200 feet from the surface. To remove paraffin from a pumping well it is usually necessary to pull the sucker rod and then to scrape the paraffin from the rod and from the tubing. Paraffin solvents have also been used to some extent but in any case the clean-out job is an expensive and time-consuming operation, necessitating shutting down the well for a more or less extended period of time.

It is a principal object of the present invention to provide a method whereby paraffin deposition in pumping wells may be reduced or prevented. Another object of the invention is to provide a novel arrangement of well equipment adapted for carrying out the method.

Other objects of the invention in part will be obvious and in part will appear hereinafter.

The rate at which crude oil can be removed from a given well is controlled by a number of factors, including the rate of production permitted by government regulation, the optimum rate fixed by the characteristics of the formation, the pumping efficiency, etc. The tubing and sucker rod sizes are also largely fixed quantities determined by the diameter of the well and mechanical factors. Thus, equipment frequently used includes a tubing having an internal diameter of about 2 inches and a sucker rod having an external diameter of about ¾ inch. With the rate of production and the equipment sizes largely fixed by factors beyond the control of the operator, the rate of flow of the crude oil up the tubing also becomes substantially a fixed quantity. Researches leading to the development of the present invention have shown that in many pumping wells where paraffin troubles are encountered the rate of production is such that the flow of the oil through the tubing is in the streamline region.

In accordance with the present invention the rate of flow of a crude oil in a pumping well is increased substantially; preferably the rate of flow is maintained at such point that in the equipment employed turbulent rather than streamline flow is attained. This is accomplished by providing a hollow rod or pipe in place of the conventional sucker rod. The rod is hollow at least from the point of substantial paraffin deposition to the surface and contains perforations leading to the interior of the rod or pipe at about this point. Thus, the method comprises flowing the oil at least from the point where substantial paraffin deposition begins to the surface through the hollow sucker rod. By this method the velocity of the flow of crude oil is increased; preferably turbulent flow is attained. It has been found that this increased rate of flow reduces or prevents paraffin deposition so that the necessity for frequent clean-outs of the well is eliminated.

The advantages obtained from the use of the present method will vary depending upon the characteristics of the well to which the method is applied. In some wells, because of the low rate of production possible, it will not be feasible to adjust conditions so as to attain turbulent flow. Even in such wells, however, by increasing the velocity of flow of oil by causing the oil to flow through the relatively small passage in the hollow sucker rod, material advantages with respect to paraffin deposition are obtainable. In other wells where the velocity of flow of crude is relatively high under present conditions of operation, the application of the present method will permit the attainment of turbulent flow.

As is well known, the determination of the characteristics of flow is made by reference to Reynolds numbers. A clear discussion of this subject appears in the chapter beginning at page 43 of the text "Principles of Chemical Engineering," by Walker, Lewis and McAdams, 2nd edition, 1927, McGraw-Hill Book Company, Inc., New York. On page 87 of the text a graph of Reynolds numbers for the flow of fluids in circular pipes is given. A Reynolds number is represented

by the ratio, Dus/z, where D represents the inside diameter of the pipe in inches, u represents the average velocity of the fluid in feet per second, s represents the specific gravity of the fluid, and z represents the viscosity in centipoises relative to water at 68° F. As shown by the figure, turbulent flow begins at Reynolds numbers above 0.15 and generally it is preferred in accordance with the invention to adjust conditions so that the Reynolds numbers are at least above 0.2. It will be understood that the results obtained by use of this formula are not absolutely accurate but they are sufficiently close approximations to determine when the turbulent flow region is clearly entered.

Thus, in any given well, knowing the average specific gravity and viscosity of the crude, it is possible to determine what velocities and diameters of hollow sucker rods should be selected in order to attain turbulent flow. In some instances it may be advisable to produce the well rapidly for a short period of time so as to increase the flow of oil and thereby, in combination with the use of the reduced diameter conduit, cause turbulent flow of the oil from the point of substantial paraffin deposition to the surface. For example, in a specific case, assuming a rate of production of three barrels per hour of a crude having a viscosity of about 8 centipoises and an average specific gravity of 0.80, the oil being produced through a flow tubing having an internal diameter of two inches and the pump being actuated by a solid sucker rod with an external diameter of ¾ inch, the Reynolds number will be about 0.04 and the flow of oil will be streamline. On the other hand, by causing this oil to flow through a hollow sucker rod having an internal diameter of about ½ inch, the Reynolds number will be about 0.2 and turbulent flow will be attained. In the latter case, due to the type of flow, the deposition of paraffin will be reduced or prevented.

In order that the invention may be understood more fully, reference should be had to the accompanying drawing in which Figure 1 represents a vertical section through a pumping well equipped to carry out the present method, and Figure 2 is a similar view of the upper portion of a well equipped differently for carrying out the present method.

Referring to Figure 1, the well shown is equipped with a casing 10, a flow tubing 11 and a header 12, which may be of the usual types. The well is producing from a producing formation A and traverses a number of other strata represented at B, C, and D. Production from the well is accomplished by means of a familiar type of tubing pump comprising a working barrel 14, a plunger 16, and a standing valve 18. The plunger is equipped with a travelling valve 20 containing a ball 22 enclosed in chamber 24 having openings 26. Standing valve 18 contains a ball 28 which is enclosed within a chamber having openings 30. At the bottom of the working barrel is attached, by means of coupling 32, a member 34 having perforations 36 through which the crude oil enters the pump. As shown, the plunger is actuated by solid section 38 of a sucker rod which is attached to the plunger by a suitable coupling 40. The sucker rod is shown as being solid for a portion of the distance from the producing formation to the surface since it is assumed the well in question is one in which the deposition of paraffin begins at some distance above the formation. Somewhat below the point at which paraffin deposition normally occurs, the solid section is coupled to a hollow or pipe section 42 by means of a screw thread coupling 44. The hollow section 42 is provided with perforations 46. The hollow section constitutes a conduit leading to the surface and into a horizontal pipe 48 having a valve 50. This pipe is connected by means of a coupling 52 to a flexible pipe or tube 54 which leads to an oil field separator or storage tank, not shown. Disposed about the sucker rod a short distance above the perforations 46 is a packer 56 which prevents the flow of crude up the tubing. The equipment also comprises a pipe 58 leading from the upper portion of the tubing, this pipe also being connected to an oil field separator or storage tank and being provided with a valve 60. The upper end of the sucker rod is connected by means of ring 62 and cable 64 to a means not shown for subjecting the sucker rod to vertical reciprocating motion.

From what has been said previously, it is believed the operation of the apparatus described will be more or less obvious. It will be recognized that the equipment with the elimination of the pump, sucker rod and packer offers a simple illustration of a means for producing a free-flowing well wherein crude passes up the tubing and to storage through line 58. After pumping becomes necessary, the well may be produced in the following manner: The packer 56 is placed in position and the sucker rod is subjected to vertical reciprocating motion, causing the flow of crude oil up the annular passage between the tubing and the solid section of the sucker rod until the packer is reached. Further flow of oil up the tubing is prevented and the oil therefore enters perforations 46 and flows through the hollow section of the sucker rod to the surface and thence through pipe 48 and flexible tubing 54 to storage. It will be noted that the flexible tubing 54 permits the reciprocating motion while at the same time affording a means of conducting the crude to the storage vessel. With the equipment disclosed, the velocity of the oil in the portion of the well containing the hollow sucker rod is increased over the velocity in the lower section of the well wherein no problem with respect to paraffin deposition exists. The crude, therefore, is caused to flow from the producing formation to the surface under such conditions as to reduce or prevent substantial paraffin deposition.

Figure 2 illustrates another manner of equipping the well so as to accomplish the objects of the invention. It will be understood that the well shown in Figure 2 is equipped in the portions thereof below the portion shown in substantially the same manner as the well shown in Figure 1. Corresponding reference numerals indicate similar parts in the two figures. In the apparatus disclosed in Figure 2, the hollow sucker rod at a point below the upper end of the flow tubing is provided with perforations 68 so as to form a connection between the interior of the hollow sucker rod and the interior of the tubing. Also, there is provided a packer 70 disposed about the sucker rod below the perforations 68 which serves to close the annular space between the sucker rod and the interior surface of the tubing. The packer permits the vertical motion of the sucker rod. Accordingly, in the operation of the equipment shown in Figure 2, the crude flowing in the hollow sucker rod flows out through the perforations 68, is prevented from flowing back down the tubing by packer 70, and is conducted to storage through pipe 58.

It will be understood in connection with the

design of equipment for carrying out the present method that the selection of hollow rod or pipe is an important factor in achieving maximum advantages from practice of the invention. In most wells a pipe having an internal diameter between ½ and ¾ inch will produce the desired results while not unduly increasing pumping costs. The wall thickness will be selected in accordance with the stresses to which the rod is subjected in operation.

It will be understood that the word "pump" is employed herein in its usual sense to include the entire pump assembly which comprises, in the type of pump shown in the drawing, the pump barrel, the standing valve and the plunger.

Obviously many modifications and variations of the invention, as hereinbefore set forth, may be made without departing from the spirit and scope thereof and therefore only such limitations should be imposed as are indicated in the appended claims.

I claim:

1. In the pumping of crude oil tending to deposit paraffin from a well equipped with a pump in the region of the producing formation, an elongated member extending to the surface and subjected to vertical reciprocating motion and actuating the plunger of said pump, and a flow tubing disposed about said elongated member through which crude oil is normally caused to flow to the surface, the method of reducing or preventing paraffin deposition which comprises flowing said crude oil at least from the point of substantial paraffin deposition to the surface through a passage of selected internal cross-sectional area in said elongated member, the rate of pumping being controlled relative to the size of said passage to cause the flow of the crude oil in said passage to be in the turbulent flow region, whereby the deposition of paraffin is reduced or prevented.

2. Apparatus disposed in an oil well producing a crude oil tending to deposit paraffin comprising in combination a flow tubing extending from the region of the producing formation to the surface of the ground, a pump actuated by vertical reciprocating motion in the region of the producing formation, an elongated member extending to the surface of the ground and disposed in said flow tubing, the external surface of said elongated member defining throughout substantially its entire length an annular passage with the inner wall of said flow tubing, means coupling said elongated member to said pump, means for subjecting said elongated member to vertical reciprocating motion and thereby actuating said pump, said elongated member having an internal passage extending at least from the point in the well of substantial paraffin deposition to the surface of the ground, said elongated member also having openings providing communication between the interior of said flow tubing and said internal passage located at a substantial distance from the surface of the ground and at least as low as the point of substantial paraffin deposition, means for closing said annular passage above said openings in said elongated member, and conduit means connected with said internal passage for conducting crude oil from the well while permitting said vertical reciprocating motion.

3. Apparatus disposed in an oil well producing a crude oil tending to deposit paraffin comprising in combination a flow tubing extending from the region of the producing formation to the surface of the ground, a pump actuated by vertical reciprocating motion in the region of the producing formation, an elongated member extending to the surface of the ground and disposed in said flow tubing, the external surface of said elongated member defining throughout substantially its entire length an annular passage with the inner wall of said flow tubing, means coupling said elongated member to said pump, means for subjecting said elongated member to vertical reciprocating motion and thereby actuating said pump, said elongated member having an internal passage in a substantial part of its length from the surface of the ground and being solid for the remainder of its length, said substantial part of the length of said elongated member extending approximately from the point of substantial paraffin deposition to the surface of the ground, said elongated member also having openings providing communication between the interior of said flow tubing and said internal passage located at a substantial distance from the surface of the ground and approximately at the point of substantial paraffin deposition, means for closing said annular passage above said openings in said elongated member, and conduit means connected with said internal passage for conducting crude oil from the well while permitting said vertical reciprocating motion.

4. Apparatus disposed in an oil well producing a crude oil tending to deposit paraffin comprising in combination a flow tubing extending from the region of the producing formation to the surface of the ground, a pump actuated by vertical reciprocating motion in the region of the producing formation, an elongated member extending to the surface of the ground and disposed in said flow tubing, the external surface of said elongated member defining throughout substantially its entire length an annular passage with the inner wall of said flow tubing, means coupling said elongated member to said pump, means for subjecting said elongated member to vertical reciprocating motion and thereby actuating said pump, said elongated member having an internal passage extending at least from the point of substantial paraffin deposition to the surface of the ground, said elongated member also having openings providing communication between the interior of said flow tubing and said internal passage located at a substantial distance from the surface of the ground and at least as low as the point of substantial paraffin deposition, means for closing said annular passage above said openings in said elongated member, said elongated member also having openings providing communication between the interior of said flow tubing and said internal passage located at about the surface of the ground and above said means for closing said annular passage, and a pipe connected with the interior of said flow tubing at about the surface of the ground for conducting crude oil from the well.

5. A method of pumping crude oil tending to deposit paraffin from an oil well, which comprises pumping said crude oil from the region of the producing formation by means of a pump the plunger of which is actuated by an elongated member which constitutes a hollow conduit of selected internal cross-sectional area at least from the point of substantial paraffin deposition to the surface of the ground, flowing said crude oil through said hollow conduit at least from the point of substantial paraffin deposition to the surface of the ground, and actuating the plunger

of said pump at a rate sufficient to cause said crude oil to flow through said hollow conduit to the surface under conditions of turbulent flow, whereby the deposition of paraffin in said well is reduced or prevented.

6. A method of pumping crude oil tending to deposit paraffin from an oil well provided with a flow tubing, which comprises pumping said oil from the region of the producing formation by means of a pump, the plunger of which is actuated by an elongated member vertically reciprocating in said flow tubing and forming an annular passage therewith, said elongated member constituting a hollow conduit of selected internal cross-sectional area at least from the point of substantial paraffin deposition to the surface of the ground, flowing said crude oil from the region of the producing formation through said annular passage formed between said elongated member and said flow tubing up to the point of substantial paraffin deposition, flowing the crude oil through said hollow conduit from the point of substantial paraffin deposition to the surface of the ground, and actuating the plunger of said pump at a rate sufficient to cause the oil to flow through said hollow conduit to the surface under conditions of turbulent flow, whereby the deposition of paraffin in said well is reduced or prevented.

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