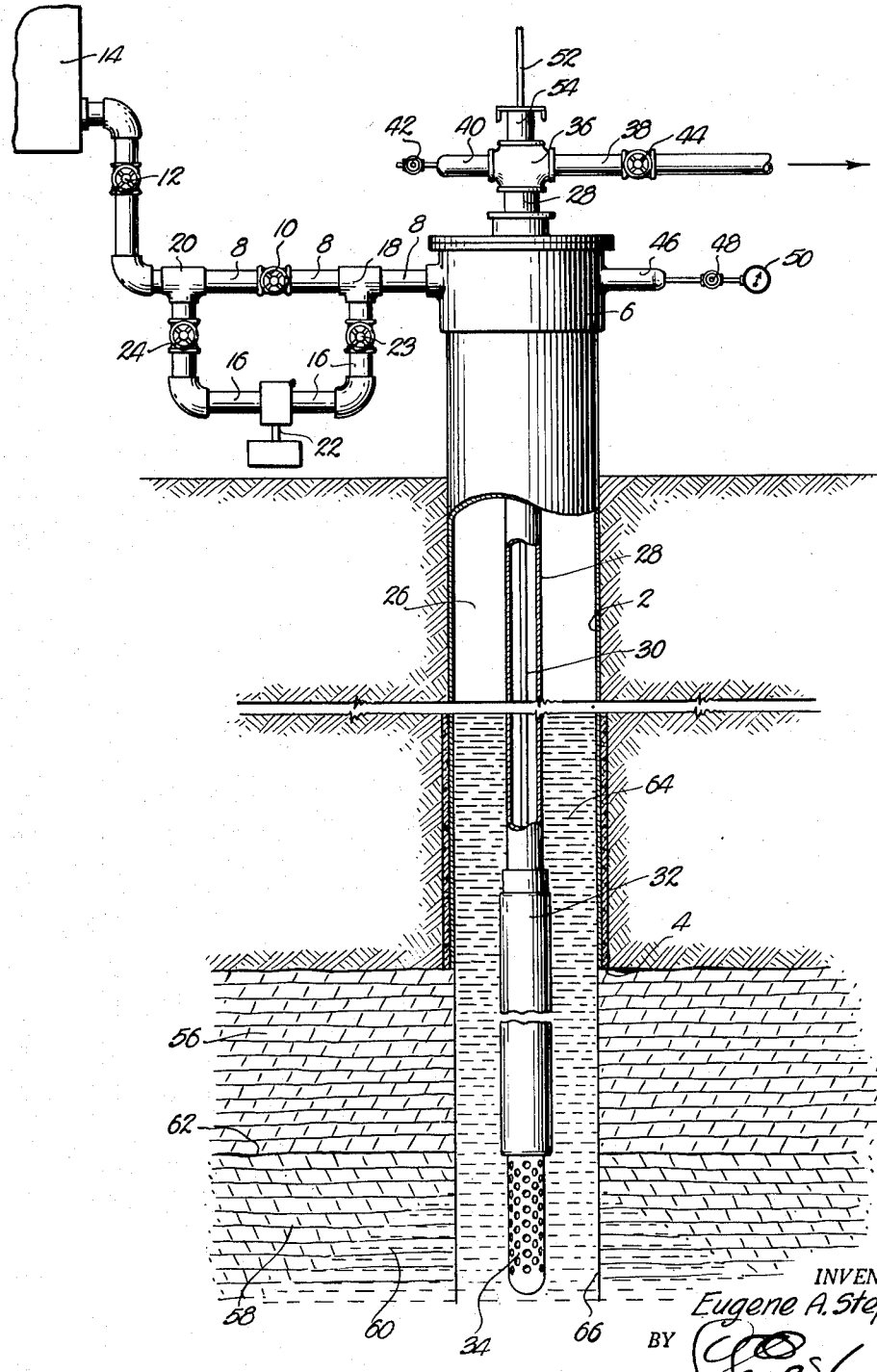
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METHOD OF TREATING OIL WELLS

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METHOD OF TREATING OIL WELLS

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1 Claim. (Cl. 166—21)

This invention relates to the art of treating oil wells of that type wherein an objectionable amount of water has appeared, or which is producing an undesirable amount of water with the oil.

The primary aim of this invention is to provide a method of treating an oil well of the aforementioned type, to reduce its production of water.

This invention has for a further object to provide a method of treating oil wells wherein has appeared a liquid column consisting of oil and water, which method includes the steps of shutting down the well a sufficient length of time for the liquid column to reach an approximately static condition, and removing collected water from the bottom of the column while oil is being deposited on top thereof in an amount sufficient to maintain the bottom-hole pressure substantially the same as that prevailing at the close of the shut-down period.

It is a further object of this invention to provide a method of treating wells of the above character, which method includes the steps of maintaining for a period of time, a pressure great enough to preclude the entrance of liquid from the sand into the well, yet low enough to prevent forcing liquid from the well into the surrounding formation, and thereafter forcing oil into said formation under pressure in excess of that prevailing at the beginning of the treatment.

A yet further aim of the invention is to provide a method of treating oil-water wells, which includes the steps of withdrawing water from near the bottom of the liquid column in the well as pressure is maintained at the surface of said column, sufficient to maintain the prevailing pressure at the commencement of the treatment, and thereafter introducing oil into the formation under sufficient pressure to force back the water therein and increase the oil saturation around the well in the formation.

An even further object of this invention is to provide a method of treating oil wells in water bearing formations, which includes the steps of forcing oil into the said formation at a velocity and pressure sufficient to suppress the water cone and increase the oil saturation within the said formation to inhibit the entrance of water into the well.

A further object of the invention is the provision of a method of treating oil wells, which includes the steps of forcing oil into the water bearing portion of the producing formation at a velocity and pressure sufficient to depress the water cone and increase the oil saturation within the formation around the well bore so as to inhibit the entrance of water into the well because of the formation of an emulsion.

This invention has for a further object to provide novel, simple and efficient apparatus for carrying out the several steps of the aforementioned method.

When practicing the invention as set forth in the foregoing objects and through employment of apparatus about to be described, the same will be capable of a large number of specific applications. For example, in the treatment of wells used in artificial water-flooding operations where it becomes desirable to reduce the permeability of streaks of the formation into which excessive portions of injected water penetrate, and thus reduce the effectiveness of the flooding process in other less permeable streaks.

The method is also applicable to the treatment of high gas-oil ratio wells through the injection of oil under pressure into selected portions of the producing formation.

The drawing is a diagrammatical illustration of an oil well partially in section, having apparatus associated therewith that permits practicing the method embodying this invention.

In the drawing, the numeral 2 designates the conventional casing which has its end 4 spaced from the bottom of the bore 66. In some practices, the casing 2 extends to the bottom of the well and is perforated adjacent the producing section of the formation. Upon the upper end of casing 2 is a high pressure casing head 6, joined to pipe 8, wherein are valves 10 and 12. Pipe 8 leads to a tank or other source of oil supply 14.

A second pipe 16 joins pipe 8 by means of two T's 18 and 20. A pump 22 is so placed in line 16 that with valves 12, 23 and 24 open and valve 10 closed, liquid may be pumped under pressure into space 26 in casing 2.

Tubing 28 is of any conventional type within which sucker-rods 30 are confined and which extend to pump 32 adjacent to the bottom of the well. A perforated anchor pipe 34 may be attached to the tubing below pump 32, and any liquid entering said pump 32 is drawn through perforations of pipe 34.

Tubing 28 extends through the high pressure casing head 6 and thence through the medium of cross 36 is placed in communication with discharge pipe 38; a pipe nipple 40 with valve 42 attached thereto is also connected to cross 36 through which the pressure in tubing 28 may be reduced or measured as needed. Pipe 38 having

valve 44 therein extends to a tank or other point of discharge.

If oil is to be introduced into bore 66 through tube 28, suitable adjustment of pump 32 and anchor pipe 34 may be made to allow the passage of oil therethrough in a direction reverse from that above described. Oil enters pipe 38 when valve 44 is open and thence reaches bore 66 by way of tube 28. As the pressure rises the level of the liquid 64 within bore 66 approaches pipe 8, through which escape is effected. Under such conditions, valves 23 and 24 are closed and valves 10 and 12 are open. The liquid so forced out of casing 2 will then enter tank 14.

The high pressure casing head 6 is also fitted with a connecting pipe 46 of the swedge type with a valve 48 connecting to a pressure gauge 50 for the measurement of pressures within the space 26 between casing 2 and pipe 28, or for the connection of other devices which are commonly used for the measurement of fluid levels in oil wells. Polish rod 52 passes through a packing gland 54, used to prevent leakage around the rod, and is attached to sucker-rods 30 by means of the commoniy used box and pin joints, not here shown.

The oil producing formation is of a character that might be encountered at any location where the oil is under what is known as natural or artificial water drive, or drive due to solution-gas or gas-cap gas. In the drawing, the oil producing zone is shown diagrammatically at 56 with zone 58—60 below it designated as the oil-water zone. The line of demarcation between 56 and 58 varies in the degree of abruptness at 62, but is usually characterized by low water saturation in the lower part of 56 and the upper part of 58 with progressive increase in water saturation with depth below the oil-water contact 62. The contact zone is normally the zone in which capillary rise exists above a fixed plane of complete water saturation. Similarly, the gas-oil contact (not shown), represents a zone of progressively greater oil saturation when passing from gas to oil zones. The rate of increase in water saturation with depth in zone 58—60 is also a function of the permeabilities of the various streaks within the formation. Zone 58—60 may also contain slugs or pockets of oil which may become recoverable through a reduction in the permeability to water in zone 58—60. Area 60 is a diagrammatic representation of what is commonly designated as a "water-cone" in and around oil-water producing wells. Within such area 60 the natural oil-water saturations have been greatly modified by water encroachment and the formation thus represented has become more permeable to water than to oil. Among the objects of the invention is to effectively exclude the water in zone 60 from contact with the well-bore, prevent the redevelopment of such a zone as 60; and overcome the possibility of water entering the bore 66 due to its rising through tortuous paths or cracks or permeable streaks in the formation 56, 58 or 60, not shown in the drawing.

The liquid column 64 in well bore 66 usually comprises both oil and water when the necessity for treating the well in accordance with this method arises.

In practice of the invention, one of the first steps is to prepare the well for treatment by shutting it down, or in other terminology "allow the well to stand idle," for a short time so as to reach an approximately stable condition. The exact time will depend upon many factors, but the principal ones will be the productivity of the well itself, the permeability of the formation, the formation pressure, the depth of the well, the production history, and the physical properties of the oil. In actual practice, it has been found that many wells reach an equilibrium condition within a period of a few hours, while others require a few days, and others many days. However, those which require extended periods in order to become stabilized are for all practical purposes, stable during the short period of time which would be required for their treatment according to the method of this invention.

A further step in the practice of the invention, unless the well is already equipped in this manner, is to dispose a pump 32 adjacent to the bottom of the well bore 66, so as to pump from column 64 the water which may underlie the oil therein. By the use of conventional means for operating sucker-rods 30 (not shown here), the latter is caused to actuate pump 32 and lift oil through tubing 28, thence through pipe 38 and opened valve 44 to a tank or other point of discharge.

As water is removed from the bottom of bore 66, oil from tank 14, or other desirable source, is caused to flow into casing 2 through pipe 8 and opened valves 10 and 12. The volume of oil deposited onto the top of the liquid column 64 should be equivalent in weight to that of the liquid being removed through tubing 28. Thus, the bottom-hole pressure is maintained constant and the continuation of the procedure will result in gradually decreasing the proportion of water in the annular space between tubing 28 and casing 2 without changing the pressure at the face of the formation 56, 58, 60 at bore 66. Liquid column 64 will gradually be converted into a column which is comprised wholly of oil without the presence of water.

A number of reasons exist for removing all water from the well bore prior to forcing the water of the formation back away from the well. Such conditioning allows the ready determination of bottom-hole pressure through a single phase liquid; eliminates any possibility of encountering suspended particles of silt that are always in the water and which would clog the face of the formation; eliminates the possibility of any water entering the oil producing formation to impede the flow of oil therethrough; and eliminates any need to determine precisely the height of the water cone to locate the position of the water in the hole. There is no inexpensive way of determining precisely the height of the water cone in a water and oil well and removal of all water, therefore, eliminates the step of trying to locate the water prior to the injection of oil under pressure.

To determine the weight of liquid being removed from bore 66, pipe 38 may be in communication with a tank of known volume, whereby the liquid may be measured and a like weight of liquid from tank 14 permitted to enter the annular space 26 above column 64. When producing the well by withdrawing liquid from the bottom of column 64, care should be exercised to withdraw liquid at a low rate of speed.

It has been discovered in the practice of this invention, that if the oil-water wells are permitted to remain idle for a few days—10 to 20—that in many cases all of the water in said wells will leave the well bores and be replaced by oil, or stated otherwise, oil accumulates on top of the water already in the well and gradually displaces the latter from the well bore. This is termed gravi-

tational displacement. Simultaneous production of the well fluids during the introduction of the oil into the well to maintain the bottom-hole pressure at equilibrium conditions, however, is preferable and should continue until the well fluid produced is 100% oil.

Examination of the liquid flowing from pipe 38 will indicate to the operator when all of the water collected at the bottom of column 64 has been evacuated.

Several advantages therefore result from pumping the liquid from the bottom of the bore hole while maintaining the hydrostatic pressure in the zone 60 constant. During the period of shutting in the well, some water in the bore hole becomes displaced into the zone at 60 and this zone becomes stable and quiescent. By maintaining the hydrostatic pressure constant during said pumping, this stability is not disturbed and no interchange of liquid will occur between the bore hole and the adjacent zone. Hence, when the final step of forcing oil into the zone 60 at high velocity takes place, a sudden flow of oil is permitted into this zone which contributes to a higher degree of emulsification of oil and water within the interstices of the formation whereby to inhibit entrance of water into the bore 66. Furthermore, no additional liquid is allowed to move into the well as the water is pumped therefrom.

When the water has been removed from the well, pressure is then applied to the column of oil 64 in well bore 66 between casing 2 and tubing 28 so as to increase the bottom-hole pressure at the face of the formation 56—58—60 by means of the pump 22 and appurtenances shown in Fig. 1, after valves 44, 42, 48 and 10 are closed and valves 12, 22 and 24 are opened.

Injection of the oil under pressure should be continued for several hours, and should be at a high rate of input. The rate of injection through the well and thence into the formation should preferably exceed that at which the well has been produced prior to treatment. Experimental work has shown that the high rate of oil injection tends to reduce the permeability to water of the water bearing portion of the formation, such as 58—60 in Figs. 1 and 2, and increase its permeability to oil. Successive injections, at intervals of a day or so have also been found beneficial in accomplishing the results indicated above.

Specifically, for wells approximately 3300 ft. deep and producing from limestone reservoirs, it has been found that rates of injection of from 6 to 176 barrels per hour are effective. Bottom-hole pressures used have ranged from approximately 1200 to 2450 lbs. per sq. in.

Crude oil which has been produced from the formation to be treated should preferably be used since such oil will be more or less in equilibrium with the minerals and water which are native to the formation. However, it should be noted that such crude oil is not necessary and other suitable liquids may be used. These liquids, specially designed to increase stability (potency) of any emulsion, are available on the open market. Such stable emulsions tend to reduce the permeability of the formation to water.

The specific manner of treating wells depends upon both past and prevailing conditions. The characteristics of the formation, the rate of producing a well prior to treatment, the productivity of the well, the static bottom-hole pressure thereof, and the rate of removal of liquid from the bottom of column 64, are all useful facts for the operator's guidance when introducing oil onto the top of column 64. These factors are given due consideration as the water is removed from the hole while the bottom-hole pressure is maintained constant. These factors are also employed in determining injection pressure, the point of injection, the rate of injection, the duration of the treatment, and the quantity of injected oil as oil is subsequently forced into the well, and the producing formation, at a pressure in excess of the bottom-hole pressure.

In many instances, adequate bottom-hole pressure information will be available from well data, which may make it unnecessary to include the step of shutting in the well or wells. If such bottom-hole pressure data are not available, the bottom-hole pressure can be computed from information as to the specific gravity of the oil and the total height of the oil column which remains in the well after gravitational displacement has taken place.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

The method of treating an oil well having a liquid column consisting of oil overlying water, and a water cone in the formation around the well bore, which includes the steps of shutting in the well a sufficient period of time for the liquid column to reach an approximate static condition; pumping liquid from a zone adjacent to the bottom of the well and supplying oil to the top of the liquid column, the weight of oil supplied being proportioned to equal the weight of the liquid being pumped from the bottom of the column whereby the hydrostatic pressure in the oil bearing formation adjacent said zone is maintained substantially constant during the period of oil supply, said pumping and oil supply being continued until all the water in the liquid column has been removed; and thereafter applying sufficient pressure to the top of the column of oil to force the oil into the formation around and adjacent to said zone to depress the water cone and to form an emulsion of oil and water within the interstices of the formation.

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