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METHOD AND MEANS FOR PRODUCING HIGH VISCOSITY
OILS AND LOOSELY CONSOLIDATED SANDS
FROM LOW PRESSURE RESERVOIRS

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Filed June 1, 1959

2 Sheets-Sheet 1

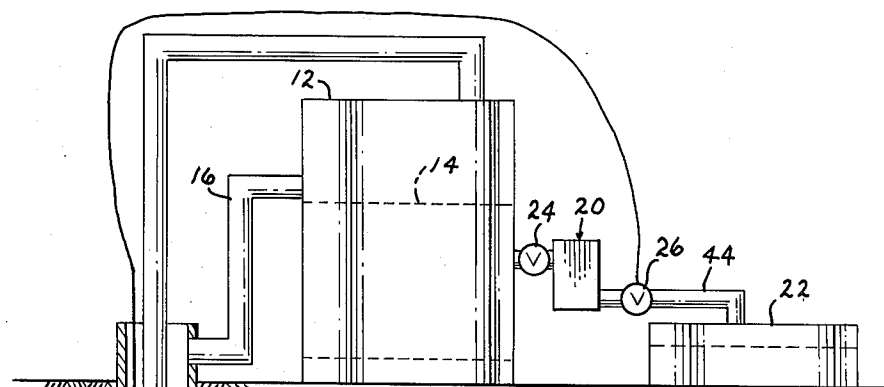


FIG. 1

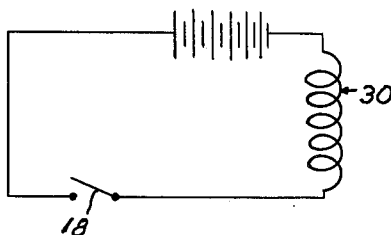
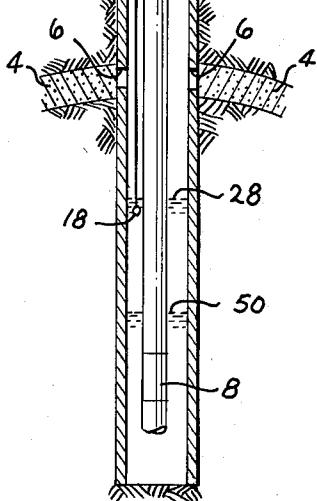


FIG. 2

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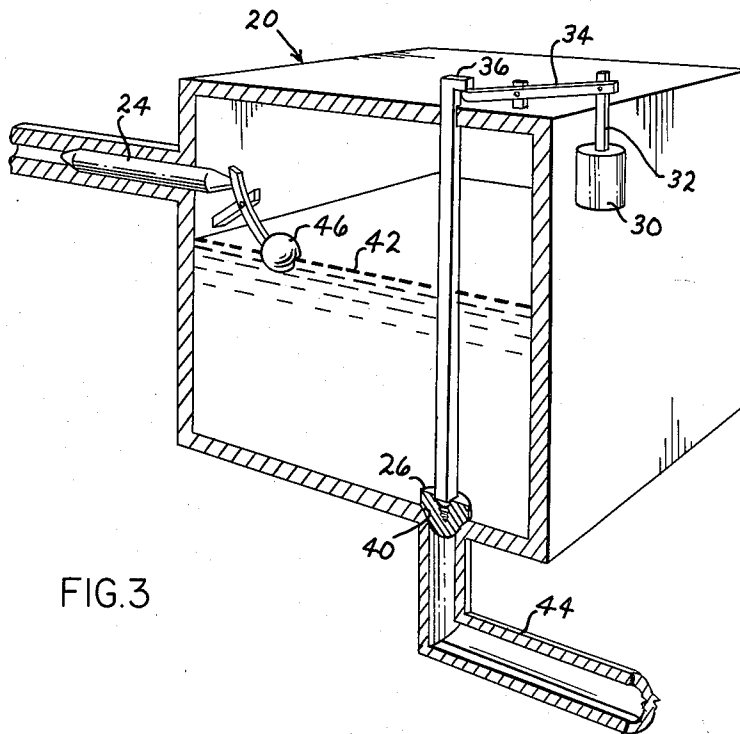


FIG. 3

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1

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METHOD AND MEANS FOR PRODUCING HIGH VISCOSITY OILS AND LOOSELY CONSOLIDATED SANDS FROM LOW PRESSURE RESERVOIRS

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There are known reservoirs of oil that are difficult to produce economically due to a combination of oil and reservoir characteristics. Sometimes a viscous oil is found in a loosely consolidated sand with a low bottom hole or formation pressure. When these conditions occur, the oil moves slowly into the well bore and carries with it the host sand. The oil and sand mixture is difficult to pump from the well bore when the volume of sand and oil is small. The difficulty arises from the fact that the sand and oil mixture tends to foul the pumping equipment when the volume of fluid being pumped is relatively low.

There are pumps which are capable of pumping up to 60% sand. These pumps, however, in order to be effective, need to move an excess of approximately 50 barrels of fluid per day. This is true because the sand carrying capacity of a fluid is partially dependent upon the velocity at which the fluid is traveling. When the velocity of the fluid being removed from the well bore is less than approximately 50 barrels per day, then sand tends to settle out of the fluid, foul the pumping equipment, and necessitate costly delays in pumping the oil from the well bore.

Sometimes attempts are made to overcome the velocity problem by placing pressure responsive switches in the well bore. With this arrangement fluid enters the well bore from the productive horizon and raises the fluid level in the well bore to a predetermined height which activates a pressure responsive switch. The pressure responsive switch, in turn, activates a pump which removes the fluid from the well bore and thereby lowers the fluid level in the well bore. When this fluid level is lowered to a predetermined point, another switch is activated to stop the pump. This system, therefore, permits intermittent high velocity removal of the fluid from the well bore. During the periods when the pump is inactivated, however, the sand has the opportunity to settle out, foul the pumping equipment, and render this system ineffective.

Another method sometimes employed to combat the velocity and sand problem is to recirculate part of the fluid being produced. In a recirculatory system the oil and sand mixture is pumped from the well bore to the surface where the sand and oil are separated. Part of the cleansed oil is then returned to the well bore to be pumped to the surface again. By recirculating part of the cleansed oil, the percentage of sand in the oil being pumped from the well bore is reduced. When the percentage of sand being pumped from the well bore is reduced, then the pumps will function in a more trouble-free manner. Also, recirculation of part of the oil being produced will permit an increase in the velocity at which the fluids are removed from the well bore.

The difficulty of the present recirculatory systems, however, is the fact that they are incapable of controlling the fluid level in the well bore. If too much fluid is returned to the well bore during the recirculation process, then the fluid level in the well bore rises. When the fluid level in the well bore rises to a point at which the hydrostatic pressure of the fluid in the well bore is equal to the formation pressure of the producing horizon, then no additional oil can enter the well bore from the producing horizon. When this situation occurs, no new oil

2

can be produced. If, however, the reverse situation occurs and too small an amount of fluid is returned to the well bore for recirculation, then the fluid level in the well bore is reduced to a point which is below the effective level of the pump in the well bore. When this situation occurs, the amount of fluid being pumped from the well bore will then be dependent upon and equal to the amount of fluid entering the well bore from the producing horizon. This, of course, will render the recirculatory system and the advantages described above ineffective.

This invention employs a fluid recirculatory system with a fluid withdrawal system controlled by a pressure responsive switch. The pressure responsive switch controls the amount of fluid withdrawn from the circulatory system and thereby controls the amount of fluid returned to the well bore. Controlling the amount of fluid returned to the well bore, in turn, controls the fluid level in the well bore, assuming, of course, the pumping capacity of the well bore exceeds the fluid producing capacity of the oil productive formation. With this arrangement the pump in the well bore may be allowed to function continuously without raising or lowering the fluid level in the well bore beyond predetermined critical limits. Also, once fluid level control is established in the well bore, the fluid may be withdrawn therefrom and recirculated at any desired velocity in excess of the productive capacity of the producing formation.

A basic object of this invention, therefore, is to provide a means and method for pumping viscous oils and loosely consolidated sands from low pressure reservoirs in an economical and trouble-free manner.

A further object of this invention is to provide a method and means whereby part of the oil being produced is recirculated in the well bore, thereby increasing the amount of oil being pumped from the well bore and improving the efficiency of the pumping equipment.

A further object of this invention is to provide a method and means for controlling the level of the fluid in the well bore and thereby controlling the amount of hydrostatic pressure exerted on the producing formation.

A further object of this invention is to provide a method and means for controlling the fluid level in the well bore and maintaining this fluid level above the effective limits of the pump in the well bore, thereby, rendering the volumetric capacity of the pump independent of the fluid producing capacity of the oil producing formation.

These together with other objects and advantages which will become subsequently apparent reside in the details of construction and operation as more fully hereinafter described and claimed, reference being had to the accompanying two sheets of drawings forming a part hereof, wherein like numerals refer to like parts throughout, and in which:

FIGURE 1 is a diagrammatic view of the circulatory system;

FIGURE 2 is a diagrammatic view of the electrical system; and,

FIGURE 3 is a diagrammatic view of the fluid withdrawal system.

Reference is now made to FIGURE 1 for an understanding of the fluid circulatory system employed. It will be noted in this diagrammatic view that the casing 2 has been extended below the sand and oil producing formation 4. The sand and oil mixture will enter the casing 2 from the producing formation 4 through perforations 6 in the casing 2. This sand and oil mixture will, of course, seek its gravitational level inside casing 2. A pump 8 forces the sand and oil mixture up the inside of the tubing 10 to a circulating tank 12 which is filled with fluid to the level indicated at 14. At the circulating

tank 12 the sand and oil mixture may be separated with chemicals, heat, mechanical separators, gravitational means, or combinations thereof. The separational means are not shown but are well known in the art. Once the sand is separated from the oil, the cleansed oil is returned to the casing 2 by means of the overflow pipe 16.

The purpose of the circulatory system described above is twofold. First, it reduces the percentage of sand to oil being pumped from the well; and second, it increases the volume of oil being pumped so the pumping equipment may function in a more trouble-free manner. Assume, for example, that ten barrels of oil and ten barrels of sand will enter the casing in a 24 hour period. Without the recirculation method this would represent a 50% mixture of oil and sand, which is very difficult to pump. If, however, 90 barrels of cleansed oil are recirculated, then the percentage of sand to oil is reduced to 10%, which is less difficult to pump.

Reference is now made primarily to FIGURE 3 in conjunction with FIGURES 1 and 2 for an understanding of the fluid control mechanism employed. In order to control the fluid level inside the casing 2, I use, in addition to the pump 8 and fluid circulating tank 12, a pressure responsive switch 18, a fluid withdrawal tank 20, and a fluid storage tank 22. The fluid withdrawal tank 20 is equipped with a float 46 controlling a needle valve 24 and a solenoid 30 controlling a valve 26. When the fluid level inside the casing 2 reaches the fluid level 28, the hydrostatic pressure of the fluid closes the switch 18 which activates the solenoid 30. Solenoid 30 exerts a downward force on a plunger 32 which is connected to a lever 34. Lever 34, in turn, exerts an upward force on a shaft 36, which lifts the valve 26 from its valve seat 40. When the valve 26 is lifted from the valve seat 40, the fluid inside the fluid withdrawal tank 20 drains to the storage tank 22 through a drain line 44. Reduction of the fluid level 42 will open the float controlled needle valve 24 allowing fluid to be withdrawn from the circulating tank 12. The fluid withdrawn from the circulating tank 12 will be replaced by an equal volume of fluid being pumped up to this tank from the inside of the casing 2 by the pump 8 through the tubing 10.

With the equipment in the aforementioned position, more fluid is being removed from the inside of casing 2 than is being returned to the well bore. This, of course, will cause a reduction of the fluid level 28. When the fluid level 28 has been reduced it will no longer exert the hydrostatic pressure necessary to maintain switch 18 in a closed position. With the switch 18 open, the solenoid 30 will be inactivated, thereby permitting the valve 26 to recede to the valve seat 40 when the fluid level 42 has been reduced a sufficient amount. When the valve 26 has receded to the valve seat 40, it will be held in this position by the hydrostatic pressure of the fluid entering the withdrawal tank 20 through the float controlled needle valve 24. The needle valve 24 will remain open until enough fluid has been withdrawn from the circulating tank 12 to raise the fluid level inside the fluid withdrawal tank 20 to fluid level 42. The amount of fluid withdrawn from the circulating tank 12 will be replaced by an equal amount of fluid pumped from inside the casing 2 through the tubing 10. Since the amount of fluid removed from the casing 2 is equal to the amount of fluid removed from the circulating tank 12 and is also equal to the amount of fluid drained from fluid withdrawal tank 20, then the fluid level 28 will be reduced to a lower level 50 which is directly proportional to the amount of fluid drained from the fluid withdrawal tank 20. Therefore, by controlling the volumetric capacity of the fluid withdrawal tank 20 and activating the withdrawal mechanism by the hydrostatic pressure of the fluid in the well bore, the fluid level inside the casing 2 can be maintained between predetermined critical limits.

It should be pointed out here that the fluid level control mechanism and the circulatory system explained above are independent of the rate at which the pump 8 removes fluid from the inside of casing 2, assuming that the pumping rate of the pump 8 exceeds the fluid producing capacity of the productive horizon 4.

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.

What is claimed is:

1. A method for pumping viscous oils and loosely consolidated sands from low pressure reservoirs which comprises introducing into the well bore a pump, a pressure responsive switch, and a string of tubing; connecting said tubing to a fluid circulating tank, said circulating tank having an overflow pipe connected to the bore and a solenoid activated fluid withdrawal mechanism connected to said circulating tank and to a fluid storage tank; operating said pump to force the sand and oil mixture up the inside of the tubing to the circulating tank, separating the sand from the oil at the circulating tank and returning part of the cleansed oil to the well bore through the overflow pipe; utilizing the hydrostatic pressure of the fluid in the well bore to activate the pressure responsive switch to control the fluid withdrawal mechanism and the amount of cleansed oil returned to the well bore; and thereby maintaining the fluid level in the well bore between predetermined limits.

2. The method of claim 1 wherein the uppermost limit of the fluid level in the well bore is controlled by the hydrostatic pressure of said fluid activating said pressure responsive switch, which in turn activates said fluid withdrawal mechanism, which in turn withdraws fluid from the fluid recirculating system and determines the amount of cleansed oil returned to the well bore for recirculation.

3. The method of claim 1 wherein the lowermost limit of the fluid level in the well bore is determined by the volumetric amount of fluid withdrawn by said fluid withdrawal mechanism, which determines the amount of cleansed oil returned to the well bore for recirculation.

4. An apparatus for pumping viscous oils and loosely consolidated sands from a casing equipped well bore communicating with a low pressure oil reservoir, comprising: a string of tubing adapted to be lowered into the well; a fluid circulating tank adjacent said well; pipe means connecting said tubing to said circulating tank; an overflow pipe extending between and connected at its respective ends to said circulating tank and the well casing; a storage tank located remote from said circulating tank; a fluid withdrawal tank interposed between and connected with said circulating tank and said storage tank; valve means connected with said fluid withdrawal tank for limiting the quantity of fluid entering the latter; valve means interposed between said fluid withdrawal tank and said storage tank; a pressure responsive switch adapted to be inserted into the well bore and connected with the last mentioned valve means for actuating the latter and releasing fluid from said fluid withdrawal tank in response to hydrostatic pressure of the fluid in the well bore; and a pump connected with the lower end of said string of tubing.

5. An apparatus for pumping viscous oils and loosely consolidated sands from a casing equipped well bore communicating with a low pressure oil reservoir, comprising: a string of tubing adapted to be lowered into the well; a fluid circulating tank adjacent said well; pipe means connecting said tubing to said circulating tank; an overflow pipe extending between and connected at its respective ends to said circulating tank and the well casing; a storage tank located remote from said circulating tank; a fluid withdrawal tank interposed between and

5

connected with said circulating tank and said storage tank; float operated valve means connected with said fluid withdrawal tank for limiting the quantity of fluid entering the latter from said circulating tank; electrically operated valve means interposed between said fluid withdrawal tank and said storage tank; a pressure responsive switch adapted to be inserted into the well bore and connected with the last mentioned valve means for actuating the latter and releasing fluid from said fluid withdrawal tank in response to hydrostatic pressure of the fluid in the well bore; and a pump connected with the lower end of said string of tubing.

6. An apparatus for pumping viscous oils and loosely consolidated sands from a casing equipped well bore communicating with a low pressure oil reservoir, comprising: a pump equipped string of tubing adapted to be lowered into the well; a fluid circulating tank adjacent said well; pipe means connecting said tubing to said circulating tank; an overflow pipe extending between and connected at its respective ends to said circulating tank

6

and the well casing for returning a selected quantity of oil to said casing; a storage tank located remote from said circulating tank; a fluid withdrawal tank interposed between and connected with said circulating tank and said storage tank; a float and valve means connected with said fluid withdrawal tank for limiting the quantity of fluid entering the latter; a solenoid valve interposed between said fluid withdrawal tank and said storage tank; and a pressure responsive switch adapted to be inserted into the well bore and connected with the last mentioned valve means for actuating the latter and releasing fluid from said fluid withdrawal tank in response to hydrostatic pressure of the fluid in the well bore.

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