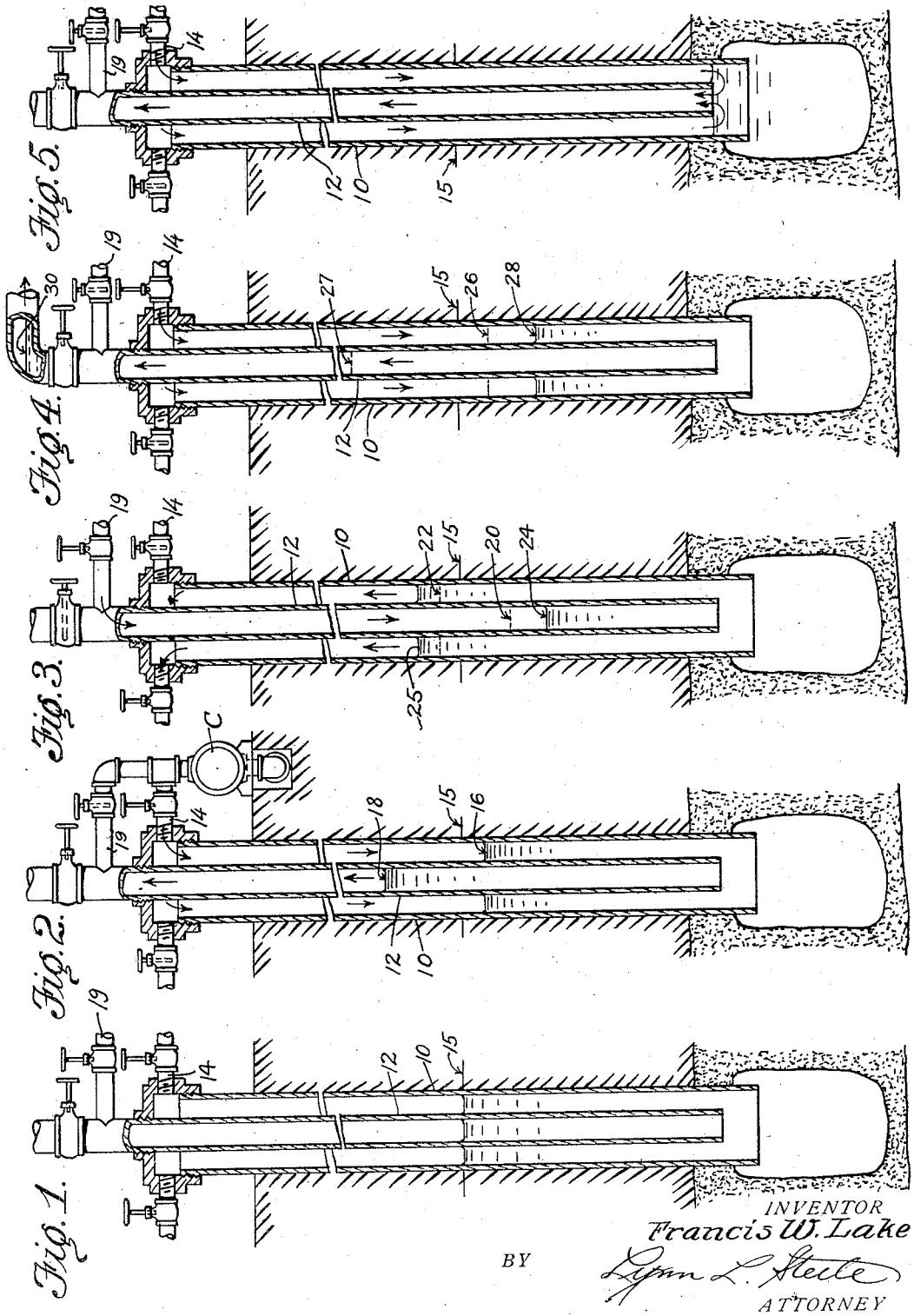
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ROCK OVER METHOD FOR ESTABLISHING GAS LIFT OPERATIONS IN OIL WELLS

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ROCK-OVER METHOD FOR ESTABLISHING GAS-LIFT OPERATIONS IN OIL WELLS

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This invention relates to the so-called "gas lift" method of flowing deep wells, particularly oil wells, and has been designed to overcome the excess hydrostatic head of oil which ordinarly accumulates in such wells prior to starting gas lift and which ordinarily cannot be removed by direct application of a reasonable gas pressure in attempting to initiate gas lift.

Gas lift, as now commonly practiced, consists in passing gas under presure into a well containing a flow tube, so that the gas passes around the lower end of the flow tube in a stream and in its passage atomizes the oil as fast as it is forced up to said tube end by the natural rock pressure in the well, the atomized oil being carried to the surface in the gas stream. The gas may be introduced either through the flow tube or through the casing, the atomized oil being discharged from the other of the two; however, it is preferred usually to introduce the gas into the casing and discharge the oil from the flow tube.

But, as above indicated, the initiation of gas lift usually offers difficulties, due to the fact that during a preceding period of idleness a relatively great hydrostatic head of oil has accumulated in the well hole, which head usually cannot be overcome by steady application of a moderate pressure to one side of the flow tube. This condition arises for the reason that, as pressure is applied to one side of the tube to depress the oil level therein, the hydrostatic head increases in the other side. While some of the oil is forced back into the formation (depending upon the viscosity of the oil, the friction of the formation, and the like) the effective rock pressure in the vicinity of the well increases until it is sufficient to balance the increased hydrostatic head. Thus, upon any attempt to start gas lift by straight application of pressure to one side in order to force over the entire excess load of accumulated oil and uncover the lower end of the tube for passage of gas thereunder, the hydrostatic head will increase until it reaches the maximum, that is, until it is equal to the entire height of the flow tube, which height may be as much as several thousand feet. Moreover, the pressure which would be high enough to start gas lift by such steady application, that is, a "normal starting pressure", under these conditions, would be excessive for all other purposes, since when the oil level is lowered and gas lift started, normal continuation of gas lift may be and should be carried on with a much lower pressure, this being made possible by the much lower density of the gas-and-oil column in the flow tube during normal gas lift as compared with the oil before gas lift. Thus, it is clear that it is not convenient or desirable to maintain said excessive pressure merely for the purpose of overcoming said hydrostatic head.

The term "hydrostatic head" except where otherwise defined, is used throughout this case to mean the pressure of that portion of the oil body accumulated in the well hole, which stands as a column in the tube and casing above the lower end of the flow tube. When a well has stood idle for a short time (a few hours or a few days according to the well), the head will have reached substantially its maximum height and will be in substantial equilibrium with the rock pressure in the vicinity of the hole. The term "rock pressure" is used to signify the natural expulsive pressure which forces the oil into the well from the formation, and under the conditions just described approximately equals said hydrostatic head in the well hole. Obviously, then, in a non-flowing well under these conditions the said rock pressure or hydrostatic head is less than the static head represented by the length of the flow tube between its points of intake and discharge.

If gas under pressure be applied to the casing for example, of a well containing an accumulated head of oil, oil will be forced up into the tube, thereby increasing the static head therein, as above indicated. Of course, if the oil level stands sufficiently high in the well, the available gas pressure may elevate the oil in the tubing sufficiently to discharge some oil from the tubing without uncovering the lower end thereof, but discharge will cease as soon as the oil level becomes depressed to such a point that the head in the

tubing above the oil level balances the gas pressure being applied.

In order to initiate gas lift by straight application of pressure, a "starting pressure" must be employed sufficient to depress the oil level low enough to allow the passage of gas under the tubing, this pressure being here termed the "normal starting pressure". Such a pressure must be at least equal to the increased static head thereby developed in the flow tube. This increased head of oil in the tubing is here termed the "normal starting head", and its magnitude is dependent upon the relative size of the tubing and casing, the amount and density and viscosity of the oil in the well, the rock pressure, the friction of the formation, etc. The "normal starting head" as the term is herein employed is defined as the "hydrostatic head" of oil in the flow tube above the point of admission to said flow tube at the time gas would break into the flow tube. In like manner, the "normal starting pressure" is defined as the gas pressure necessary to depress the oil level in the gas admission tube to the point of gas admission to the flow tube and sufficient to start gas lift in the flow tube when said pressure is applied to the surface of the oil in said gas admission tube. It is observed that the definition applies whether discharge flow is from the tube and gas application is through the casing, or vice-versa. If a gas tube is employed and is connected by a jet to the flow tube in a manner common to air or gas lift, the starting head or pressure may be equal to the hydrostatic head of the oil in the flow tube above the jet when gas is first forced into the gas tube, and it may be equal to or slightly greater than the hydrostatic head of oil above the jet when first applied.

The general object of the present invention, is to overcome the hydrostatic head and depress the oil level approximately to the lower end of the flow tube by the application of gas under a pressure less than that required to initiate gas lift by steady application to either the tube or the casing in the usual manner, and less than the hydrostatic head naturally existing in the well prior to gas lift initiation.

This object is attained by promoting the absorption of a large amount of gas (natural gas preferred) by the oil body, coupled with a depression of the oil level to as low a point as possible with the available pressure, whereby the absorbed gas materially reduces the specific gravity of at least the upper portion of the oil body and whereby the availble pressure then becomes sufficient to elevate and discharge the column of the so-lightened oil in conjunction with the expansive and lifting properties of the absorbed gas.

For convenience the present method is termed the "rock-over" method, since it comprises producing a series of impulses in one direction alternated with impulses in the opposite direction for the purpose of alternately raising and lowering each of the oil columns in the tubing and casing, the impulses being timed and applied to raise the rising column higher and higher in each instance until the rising oil column is eventually forced out at the top, this effect being assisted by gas which has been absorbed under the pressure produced and by the agitation resulting from the alternating or rocking action.

Essentially, therefore, the invention resides in introducing into a well a quantity of gas such as air but preferably a soluble gas such as natural gas, under a pressure which, if steadily applied, is insufficient to overcome the normal starting head of the well, this gas under pressure being applied first to one side of the tubing and then to the other, while the opposite side is released in each instance, so as to rock the two oil columns to and fro as above indicated and to agitate and mix the oil body in the casing and in the flow tube whereby appreciable quantities of gas are absorbed by the oil and serve to lighten the oil columns, this absorbed gas being capable of expanding in the upper portion of the column to be discharged so that such expansion eventually will assist the operation sufficiently to carry over at least a small proportion of the oil body, and repeating the alternate pressure applications as often as necessary to establish flow.

Subject matter disclosed but not herein claimed, together with various modifications of the generic invention, is covered in my copending applications, Serial Numbers 206,677 and 206,679.

In the accompanying drawings wherein oil movements are represented diagrammatically,

Fig. 1 indicates the oil level as it stands initially in the casing and flow tube;

Fig. 2 indicates the first operation of a method which is usually practiced wherein gas under pressure is applied to the casing outside the flow tube;

Fig. 3 indicates the second operation wherein the pressure application is reversed and applied to the flow tube at the proper time;

Fig. 4 indicates a subsequent operation wherein the pressure is again applied to the casing and the quantity of oil is thereby pushed out from the top of the flow tube.

Fig. 5 indicates the condition finally attained, that is, normal gas lift.

In these drawings there is shown a well casing 10 into which a flow tube 12 depends through the casing head, said casing head being also provided with a connection 14 through which gas under pressure may be introduced from compressor C. The level of the oil which has accumulated in the tube and

the casing prior to institution of gas lift proceedings is indicated by line 15, it being the function of the present invention to reduce this static head by forcing said oil level down to the lower end of the flow tube 12 whereby gas will flow under said tube to atomize the oil and thereby initiate normal gas lift.

Ordinarily, the operation is started by first applying the gas under pressure to the surface of the oil in the casing, said gas being introduced through the connection 14 and the flow tube 12 being left open at its upper end. The pressure is built up in the casing to the available maximum to cause the oil level to rise in the tube as high as possible and until the static head of oil in the tube equalizes said pressure, the depressed oil level in the casing being indicated at 16, and the level attained in the tube being indicated at 18 in Fig. 2. Under these conditions some oil may be forced back into the formation, thus further lowering the oil level. The pressure in the casing is then released and the gas under pressure is transferred to the flow tube by way of connection 19 to follow up the gravity descent of the oil column so as to take advantage of the momentum of such descending column. Under this pressure application the oil level in the casing is elevated to as high a point as possible, by depression of the level in the tube to as low a point as possible. In Fig. 3 the dotted line 20 represents the probable limit of descent of the oil column in tube 12 which would occur by gravity and momentum alone and the dotted line 22 represents the corresponding elevation in the casing, while the line 24 represents the depression of the oil in the column 12 under the application of pressure, and the line 25 indicates the corresponding elevation in the casing. These points having been reached the tube pressure is released and gas under pressure is again applied to the casing, the momentum of the moving oil again being relied upon to assist depressing the oil column as far as possible. This alternate application of gas under pressure on one side with released pressure on the other side, is repeated as often as necessary and the oil columns are thereby caused to surge back and forth in conjunction with the influences of gravity and momentum whereby an appreciable amount of agitation is produced and contact of the oil with the gas is increased with a resultant increase in gas absorption, which absorption, of course, is materially assisted by the pressure under which the gas is introduced. The gravity descent of the oil column in the casing, which eventually perhaps would reach point 26 with a corresponding elevation in the tube to the point 27, taken in conjunction with the application of pressure to the casing through the connection 14 will cause an eventual depression of the oil level in the casing to the point 28 as indicated in Fig. 4 with a consequent elevation of the oil in the flow tube to the over-flow level 30 whereby at least a portion of the oil column is discharged.

Obviously, in view of the gravity descent of the oil columns, rock-over could be accomplished by pressure impulses to one side only if the head were sufficiently low.

All of the alternate pressure applications are properly timed at intervals to correspond with the beginning of descent of the respective oil columns, this timing being determined by watching the pressure gauges; the result is that said columns are caused not only to surge back and forth but also to rise higher and higher on the respective sides until a quantity of the oil is sent over. It is important that this rocking or surging motion be so timed as to obtain the maximum surge with the greatest possible rapidity, since such timing results in taking the greatest advantage of the momentum of the moving oil columns. In this fashion the combined influence of such momentum of the oil bodies, together with the pressure under which the gas is introduced and the expansive influences of the absorbed gas, eventually result in establishing continuous flow from the well, by depression of the oil level to approximately the lower end of the flow tube 12 as indicated in Fig. 5, so that the gas will flow around the lower end of said tube, thereby atomizing the adjacent oil and carrying it upward through the tube in amounts corresponding to the natural oil flow into the well. Ordinarily, flow may then be continued with a lower pressure than was required for starting.

Usually it is not possible to cause flow of any great amount of oil over the top in the beginning, since the head of the relatively heavy oil in the flow tube above the level in the casing will become too great to be overcome by the gas pressure. But at each successive impulse an additional small amount of oil ordinarily will be expelled and at each operation additional amounts of gas will be absorbed until the oil body is sufficiently reduced in volume and becomes sufficiently reduced in gravity by gas absorption or entrainment to enable the available pressure to push the lightened oil column from the flow tube and establish normal gas lift. Obviously normal flow, if desired, may be established from the casing rather than from the tubing and it is to be understood that the invention is the same regardless of the direction of the flow finally established, especially since the initiating steps will be the same.

The method above outlined may be varied by keeping the flow tube closed for a time when the casing is placed under pressure, in order to increase gas absorption. Sometimes when the hydrostatic head is low and only a slight amount of absorption and agitation is required to start gas lift, the well will commence to flow upon sudden release of this

pressure in the tubing. Obviously this step also may be reversed.

As an example of one method of operation and where it was impossible to force over the head of oil by straight application of gas at 800 lbs. pressure, the alternate application and release of a pressure of 500 lbs. first on one side and then on the other to get the oil columns rocking to and fro, succeeded in discharging the excess oil and starting gas lift, a pressure of 175 lbs. or 200 lbs. being sufficient to continue gas lift.

It is to be understood that the above disclosures are merely illustrative, and that many variations of the invention may be made within the scope of the following claims as will be apparent to those skilled in the art.

I claim:

1. In a method for initiating gas lift in an oil well containing a casing and a body of oil into which a flow tube depends, the steps comprising introducing gas under pressure into the casing on one side of the tube to elevate a column of oil on the other side of the tube, releasing the pressure and allowing the elevated oil column to return to be mixed with said body of oil.

2. In a method for initiating gas lift in an oil well containing a casing into which a flow tube depends, the steps comprising introducing gas under pressure into the casing to approximate the maximum pressure attainable with the available pressure whereby the oil body becomes charged with a gas, releasing the pressure in the casing, and repeating these operations until the oil becomes charged with gas sufficient to insure discharge of a portion of the oil.

3. In a method for initiating gas lift operation in an oil well containing a casing into which a flow tube depends, the steps comprising introducing gas under pressure into the casing whereby an oil column is elevated in the tube and the oil body becomes charged with gas, releasing the pressure in the casing and allowing the oil column to return, repeating this operation until the oil becomes charged with gas sufficient to insure discharge of a portion of the oil, then placing the casing again under pressure and venting the flow tube to discharge a portion of the charged oil.

4. In a method for initiating gas lift operation in an oil well having a casing containing a body of oil into which a flow tube depends, the steps comprising introducing gas into the casing under pressure less than the normal starting pressure whereby said pressure elevates the oil column in the tube, releasing the pressure in the casing and allowing the oil column to return, repeating this operation until the oil becomes charged with gas sufficient to insure discharge of a portion of the oil, then placing the casing again under pressure and venting the flow tube to discharge a portion of the charged oil, and repeating this operation to force out successive portions of the oil until the level in the well is lowered sufficiently to establish normal gas lift operation.

5. In a method for initiating gas lift operations in an oil well containing a casing in which the flow tube depends, the steps comprising introducing gas under pressure into the casing to approximately the maximum pressure attainable with the available pressure and for elevation of an oil column in the tube, releasing the pressure in the casing to allow said oil column to descend and simultaneously applying the available gas pressure to the descending column until said descending column has been depressed as far as possible, releasing the pressure in the tube to allow the oil column in the casing to descend, and repeating these operations until normal gas lift is established.

6. In a method for initiating gas lift operations in an oil well containing a casing into which a flow tube depends, the steps of introducing gas into the casing under pressure less than that normally required to force gas under the lower end of the flow tube, to depress the oil body in the casing as far as possible and to elevate an oil column in the tube as far as possible with said pressure, releasing the pressure in the casing to allow the oil column in the tube to descend and simultaneously applying pressure to the tube to depress the column therein as far as possible, releasing the pressure in the tube and repeating the above steps to establish normal gas lift.

7. In a method for initiating gas lift operations in an oil well, the steps comprising bringing gas under pressure into contact with the surface of an oil body in a well, and agitating the oil to charge the same with gas.

8. In a method for initiating gas lift operations in an oil well, the steps comprising bringing a soluble gas under pressure into contact with the surface of an oil body in a well, and agitating the oil by fluctuating the level thereof to charge the oil with the gas.

9. In a method for initiating gas lift in oil wells, the steps comprising bringing gas under pressure into contact with oil in a well into which a tube depends and by variation in gas pressures upon the opposite sides of the tube causing the oil body to rock to and fro whereby the oil is mixed with and becomes charged with gas.

10. In a method for initiating gas lift in an oil well containing a casing and a body of accumulated oil into which a flow tube depends, the steps comprising alternately applying series of impulses on opposite sides of the flow tube to alternately raise and lower the oil columns in the tube and casing.

11. In a method for initiating gas lift in an oil well containing a casing and a body of accumulated oil into which a flow tube de-

pends, the steps comprising applying gas under pressure in a series of impulses applied to one side of the tube alternately with a series of impulses applied to the other side of the tube for alternately raising and lowering the oil levels on the respective sides, the opposite side being released to atmosphere on each pressure application.

12. In a method for initiating gas lift operations in an oil well containing an accumulation of oil and wherein a flow tube depends within a casing, the steps comprising bringing gas into contact with the oil in the well under a pressure less than the hydrostatic head of the oil for absorption of gas by the oil, suddenly releasing the pressure on one side and applying it on the other side to produce a surging and mixing of oil and gas, and repeating this operation until the column of oil on the released side becomes sufficiently lightened by the absorbed gas for the establishment of normal gas lift.

13. In a method for initiating gas lift operations in an oil well wherein a flow tube depends within a casing, the steps comprising bringing gas under pressure into contact with oil in the well, suddenly releasing pressure on one side and applying it on the other to produce a surge of the oil and a consequent mixing of oil and gas, repeating this operation until the column of oil on the released side becomes sufficiently lightened by absorbed gas for discharge of at least a portion of the oil body.

14. In a method according to claim 13 wherein the operations are further repeated to cause the discharge of successive portions of oil until the oil level is reduced to a point at which the available gas pressure is sufficient to establish normal gas lift.

15. In a method for establishing gas lift in oil wells wherein a flow tube is positioned within the well casing, the steps comprising bringing gas under pressure into contact with an accumulated body of oil on one side of the tube while leaving the other side free, releasing the pressure on the one side of the tubing and applying it to the other side.

Signed at Los Angeles, in the county of Los Angeles and State of California, this 12th day of July, A. D. 1927.

FRANCIS W. LAKE.