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L. C. UREN

PROCESS AND APPARATUS FOR INCREASING THE RECOVERY OF PETROLEUM FROM WELLS

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Fig. 1.

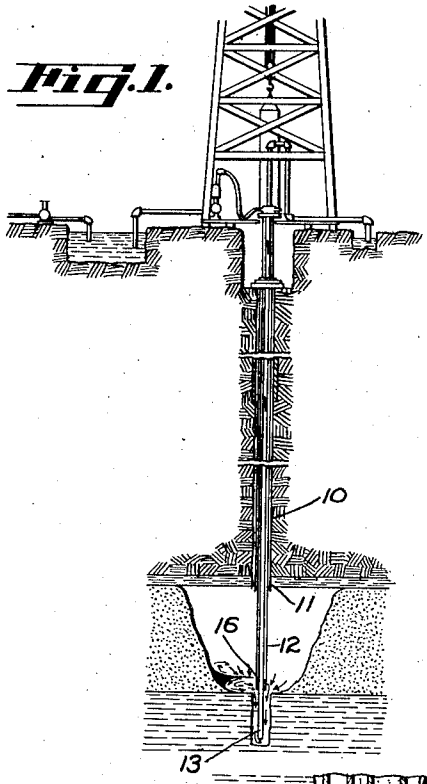


Fig. 2.

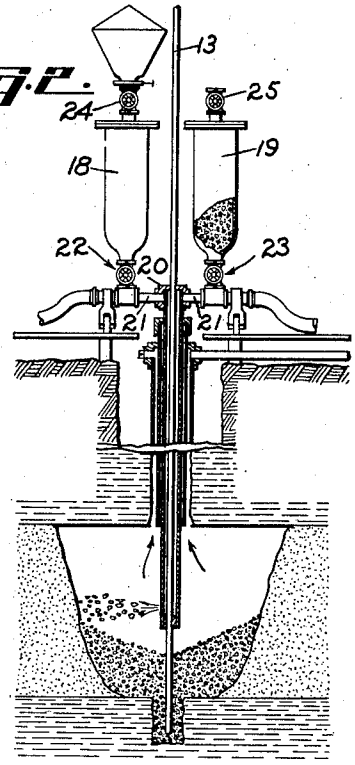
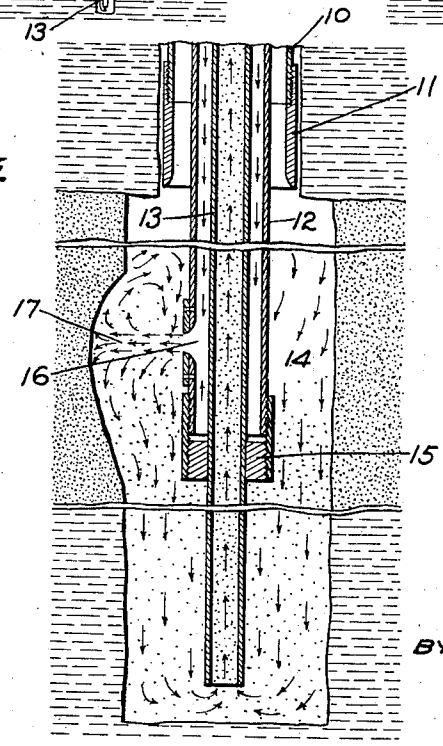


Fig. 3.



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UNITED STATES PATENT OFFICE.

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PROCESS AND APPARATUS FOR INCREASING THE RECOVERY OF PETROLEUM FROM WELLS.

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To all whom it may concern:

Be it known that I, LESTER C. UREN, a citizen of the United States, residing at Berkeley, county of Alameda, and State of California, have invented new and useful Improvements in Processes and Apparatus for Increasing the Recovery of Petroleum from Wells, of which the following is a specification.

This invention relates to methods and equipments for producing petroleum from wells.

The invention is particularly concerned with a process and apparatus for increasing the recovery of petroleum from wells, the application of which will result not only in increasing the rate of production, but will also lead to an increase in gross or ultimate recovery.

Petroleum occurs in nature as a fluid saturating or partially saturating the voids or pore spaces between the grains of porous rocks or aggregations of rock particles, such as sand, sand stone, conglomerate, shale, limestone, etc. The oil, under the influence of gas pressure, hydrostatic pressure, gravity, earth pressure and perhaps other natural forces, is caused to flow or migrate through the porous reservoir rock into wells penetrating the stratum or strata in which the oil occurs. The wells, providing outlets to the surface, are centers of reduced pressure, and the flow of the rock fluids into a particular well is usually an expression of the difference in pressure existing between the space within the well and that of the stored oil within the reservoir rock. The greater this differential pressure, the more rapidly will oil flow from the source rock into the well. Opposing movement of the oil from the reservoir rock into the well are certain natural forces related to the rock structure, such as pore friction, adhesion, capillarity, and others related to the physical properties of the oil, such as viscosity and density. The differential pressure between the well and the boundaries of the area drained by it, must be sufficient to overcome the forces opposing flow if there is to be movement of oil into the well. It follows that if by any device the resistance to movement of the oil may be reduced, the oil will flow into the well at a more rapid rate and the effective area of drainage will be increased. It is the purpose of this invention to provide a method and a means of reducing this resistance to flow.

This invention comprises a process and a means for accomplishing the enlargement of wells where they penetrate oil-saturated porous rocks, so that the benefits accruing from the increased rate of oil production may be realized. The process involves the use of hydraulic force applied with the aid of a pump or otherwise, against the oil bearing rock or sand in a direction other than parallel with the axis of the well, with the intention of enlarging the well by disintegrating the rock or sand so that detached particles flow into the well whence they are removed to the surface with the aid of a compressed air lift, an air displacement pump or ejector, or by circulating, bailing, swabbing, pumping or other known means of removing loose granular material from wells. The fluid used in applying such hydraulic force to the walls of the well may be either water, crude petroleum, a chemical reagent capable of acting chemically upon the rock, or a liquid product obtained by distilling petroleum or other substance in which hydrocarbons are soluble. The circulating fluid, if of value, may be used repeatedly with small loss, by arranging that it shall be discharged as it flows from the well at the surface into a suitable tank or sump in which the sand settles out and from which it is taken by the suction of the pump for further circulation through the well. Through the continued or repeated use of this process, the walls of the well within the oil-bearing strata or stratum are eroded away by the impinging force of the fluid directed as a jet from a nozzle placed in the tubing which conveys the fluid into the well; and the detrital material so loosened from the walls, is either intermittently or continuously removed from the well by suitable means as above suggested.

The method of applying the process will necessarily vary somewhat with the conditions imposed, particularly with the character of the oil-bearing rock and the depth of the well. If the oil bearing stratum is a sand or a loosely cemented sandstone, the procedure outlined below may be successfully employed to enlarge the well.

The invention is illustrated by way of

example in the accompanying drawings, in which:

Fig. 1 is a view in central vertical section through an oil well showing the application of the present invention and with parts broken away for sake of convenience.

Fig. 2 is an enlarged view in central vertical section showing parts of an oil well, and more clearly disclosing the manner in which the enlarged cavity is filled with granular filtering material.

Fig. 3 is an enlarged view in central vertical section showing the erosion nozzle and the manner in which it projects a jet of fluid horizontally to form a cavity at a point in the bore of the well.

The lower part of the well, where it passes through the oil stratum, is cased with a column of screen pipe 10, the lower end of which is equipped with a steel shoe 11. This string of pipe is raised to the position shown in Fig. 1 and the hole is then underreamed to as large a diameter as may be practicable, from the top of the oil bearing stratum to the bottom of the well. Two "strings" of tubing 12 and 13, one within the other, are coupled and lowered into the well to the position indicated in Fig. 1. Both 12 and 13 are continuous and extend to the surface. The outer pipe 12 has a coupling 14 in its lower end into which plug 15 is screwed, the plug having a hole bored through its center just large enough to admit pipe 13 without excessive friction. The lower portion of pipe 13 extending through the oil bearing stratum, is welded together with smooth joints, so that plug 15 may slide freely over it. Near its lower end, a few inches above plug 15, pipe 12 is pierced by one or more round openings 16 suitably reinforced, the opening being shaped to the form of a nozzle so that fluid ejected through it from within pipe 12 will take the form of a jet 17. Pipe 13 is suspended so that its open lower end is a foot or two off bottom, while pipe 12 is suspended within the derrick on a swinging spider in such a way that it may be raised or lowered or turned. (See Fig. 1.) A pump or a pair of pumps connected in tandem, capable of developing high pressures, is connected with one of the side outlets of the stuffing box casing head on pipe 12 and the pump suction connects with an oil storage tank or sump containing sufficient crude petroleum to fill the well. A second stuffing box casing head closes the space between pipe 12 and casing 10 and its conductor string.

The well, or that part of it within the conductor casing enclosing casing 10, is first filled with oil, pumping the oil down between pipes 12 and 13 with pipe 12 lifted so that the oil jet 17 impinges against the inner walls of casing 10, or preferably against its shoe 11. This prevents the jet from loosening the oil sand until the well is full of oil. (Otherwise the bottom of the well may become clogged with sand.) With the well filled with oil and all outlets securely closed except through pipe 13, oil is pumped down between pipes 12 and 13 under high pressure. Pipe 12 is lowered until jet 17 impinges directly upon the oil sand forming the walls of the well. As the jet detaches particles of sand from the walls of the well, the detrital material falls into the sump below the oil stratum, and is swept up through pipe 13 by the force of the rapidly flowing oil. Slowly lowering or raising pipe 12 and turning it through 360 degrees brings all parts of the walls within the influence of the jet. Oil carrying detrital material is discharged into a sump at the surface by pipe 13, the sand settles out in the sump and the oil is taken up by the pump suction for further circulation through the well. Gradually the well is enlarged until its diameter is materially greater than the original bore.

The efficiency of the jet in disintegrating the walls will rapidly decrease as the hole is enlarged, due to dissipation of its force by the surrounding fluid. Hence the pressure must be gradually increased as the work progresses. Much may be accomplished by taking advantage of the tendency of the oil sand to cave and to establish its natural slope of repose. With this in view, the jet is first lowered to a point near the bottom of the oil stratum. The cavity thus formed will result in caving of the over-lying sand, which may then be rapidly broken up with the jet by working systematically upon it. The enlarged cavity about the well should extend up to the cap rock which, due to its harder and more resistant nature, will not cave unless the cavity is made unduly large. If a pump pressure as high as one thousand pounds per square inch is available, it is considered feasible by the method outlined above to form a cavity in a fifty foot oil sand that will be ten feet in diameter at the bottom and thirty feet in diameter at the top. A cavity of such proportions should result in approximately doubling the rate of production of a six inch well.

In loosely cemented sands which display a tendency to cave or flow into the opening created by the jet applied as above described, it will be desirable to fill the cavity about the well with some solid, porous material offering no great resistance to movement of oil through it, such as crushed rock or gravel. The walls of the cavity will not cave seriously or flow in with the oil as long as the well is filled with oil and is under the influence of the pump pressure, the hydrostatic head thus created being sufficient to sustain the walls. After excavation of the

cavity has been completed and before the oil in the well has been bailed or pumped down to normal levels, the jet is used to fill the cavity with the filling material. Assuming that gravel is the filling material adopted, it may be fed into the descending stream of oil between pipes 12 and 13 with the aid of the equipment illustrated in Fig. 2. In Fig. 2, 18 and 19 are gravel containers supported in a vertical position above casing head 20, and connecting with pipe 21 through which oil is pumped into the space between pipes 12 and 13 extending to the jet applied within the cavity in the oil sand. The pumps and circulating fluid are operated in the same manner as described above for the formation of the cavity, except that the outlet from pipe 13 is closed and the fluid is permitted to flow back to the surface between pipe 12 and its conductor casing 10.

The gravel containers 18 and 19 are equipped with suitable valves 22 and 23, where they make connection with pipe 21 and with other valves 24 and 25 at their upper ends. With the upper valves closed and the lower valves open, the interior of the gravel containers may be maintained under the full pump pressure and in direct connection with the oil circulating system. Gravel of suitable size to pass freely through the valves between pipes 12 and 13 and through the nozzle 16, is charged into 18 and 19, the upper valves 24 and 25 are closed, and either 22 or 23 is opened. With the pumps working under high pressure and with fluid flowing down between pipes 12 and 13 out into the well cavity through nozzle 16 and back to the surface between 12 and the conductor casing 10, gravel enters the circulating system, is swept down through the annular space between pipes 12 and 13 through the nozzle 16 and deposited in the well cavity. If the volume of the circulating fluid be so adjusted that the oil flowing back to the surface has insufficient velocity to lift the gravel, it will accumulate in the bottom of the well and in the well cavity until the latter is filled.

In placing the gravel, the jet is first lowered to a point near the bottom of the cavity and then raised slowly and turned back and forth as the gravel accumulates. Gravel containers 18 and 19 are connected with the circulating system alternately, one being refilled while the other is feeding its material into the well. They may be readily refilled with the aid of a loading apron which is shoveled full of gravel on the derrick floor, hoisted up into the derrick above the containers and connected with one or the other of the upper valves 24 and 25 so that gravel flows by gravity from the apron into the container.

After the well cavity is completely filled, pipes 12 and 13 are withdrawn and screen pipe 10 is lowered to bottom. Some of the gravel may cave into and partially fill the hole left by withdrawing pipes 12 and 13, but this material will be readily pushed aside by the shoe or screen pipe 10 as it is lowered to the bottom of the cavity. Any gravel remaining within pipe 10 after it is placed on bottom may be bailed out with a sand pump. The permanent pumping device may now be lowered within the screen pipe and the well placed on production.

Though a definite method of procedure for accomplishing excavation and refilling of a cavity has been described in some detail, it is not intended to imply that this is the only method claimed under this application by which the desired result may be effected. For example, under certain conditions the air lift might be utilized to remove the fluid jetted into the well cavity, and if there were sufficient submergence for the air lift nozzle, the fluid and sand might be removed from the well as fast or faster than it accumulates, so that the jet is applied directly against the wall of the well without the reduction in its effective force which results from the accumulation of fluid about it. Many different systems of piping and forms of jets may be devised for particular purposes or conditions. Different circulating fluids may be used as already suggested. Different methods of removing the detrital material loosened by the jet may be employed. The gravel or other filling material may be placed by other means than by the method suggested. In well-cemented rocks which do not cave readily, it may not be necessary to refill the cavity. Mention herein of materials and of modifications in procedure and in apparatus is by way of example, and is not exclusive of other modifications within the spirit of the following claims.

Aside from the increased rate of production possible with the larger diameter of well, the placing of gravel or other similar porous material about the perforated pipe through which oil enters the well, would largely reduce the amount of "float" sand that continually finds its way into the well when not so protected. Difficulties due to sanding up of the well and the pumping device and wear on the moving parts of the pump will therefore be greatly reduced.

It will thus be seen that the apparatus and method here provided for increasing the effective flow of an oil well is relatively simple in its construction and the manner in which it may be practiced, and it is further evident that the method may be carried out without materially interfering with present day oil boring practice.

While I have shown the preferred form of my invention as now known to me, I wish it understood that various changes may be

made in its construction without departing from the spirit of the invention as claimed.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. A method of treating oil wells which consists in delivering a flow of fluid to a point in the oil sand stratum of the well, and there projecting a jet of the liquid substantially at right angles against the side walls of said sand, and simultaneously withdrawing the spent liquid and the detrital material from the well and through the shaft; and then delivering insoluble granular material through the shaft to the cavity formed by the action of said liquid jet, whereby the walls of the cavity will be supported against caving, and the liquid drawn from the surrounding stratum will be filtered.

2. An apparatus of the class described comprising a well casing member adapted to be projected downwardly in a well bore, a jet opening in said casing member for projecting a fluid from the casing in a plane at right angles from the longitudinal axis of the casing, and a central tube disposed within the casing and through which said spent liquid with detrital material may be withdrawn from the well, and means for delivering an insoluble granular material through the casing to the cavity formed by the erosive action of said liquid.

3. A method of introducing insoluble granular material within a cavity surrounding a well shaft which consists in circulating a liquid down the shaft to the cavity and then withdrawing it therefrom and supplying the downwardly flowing stream with granular material to be deposited in the cavity.

4. An apparatus for introducing insoluble granular material into a cavity surrounding a well shaft comprising outer and inner casings disposed one within the other, the outer casing being closed around the inner casing at its lower end, and said casing being formed with an outlet near its lower end, means for creating a flow of liquid down the outer casing and around the inner casing to said outlet and for permitting said liquid to return to the surface of the ground with additional circulation of liquid down through the inner casing, and means for introducing insoluble granular material into the downwardly flowing stream of liquid whereby it may pass out through the opening at the bottom of the casing and fill the surrounding cavity of the well.

5. An apparatus for introducing insoluble granular material into a cavity surrounding a well shaft comprising an outer casing, a casing extending downwardly therethrough, said second named casing being substantially closed at its lower end and being further formed with an outlet opening near said closed end; means for creating a downward flow of liquid through said second casing and into the well bore through said opening and means for adding insoluble granular material to said down stream of liquid whereby it will pass through the opening in the casing to fill the surrounding cavity of the well bore.

LESTER C. UREN.