

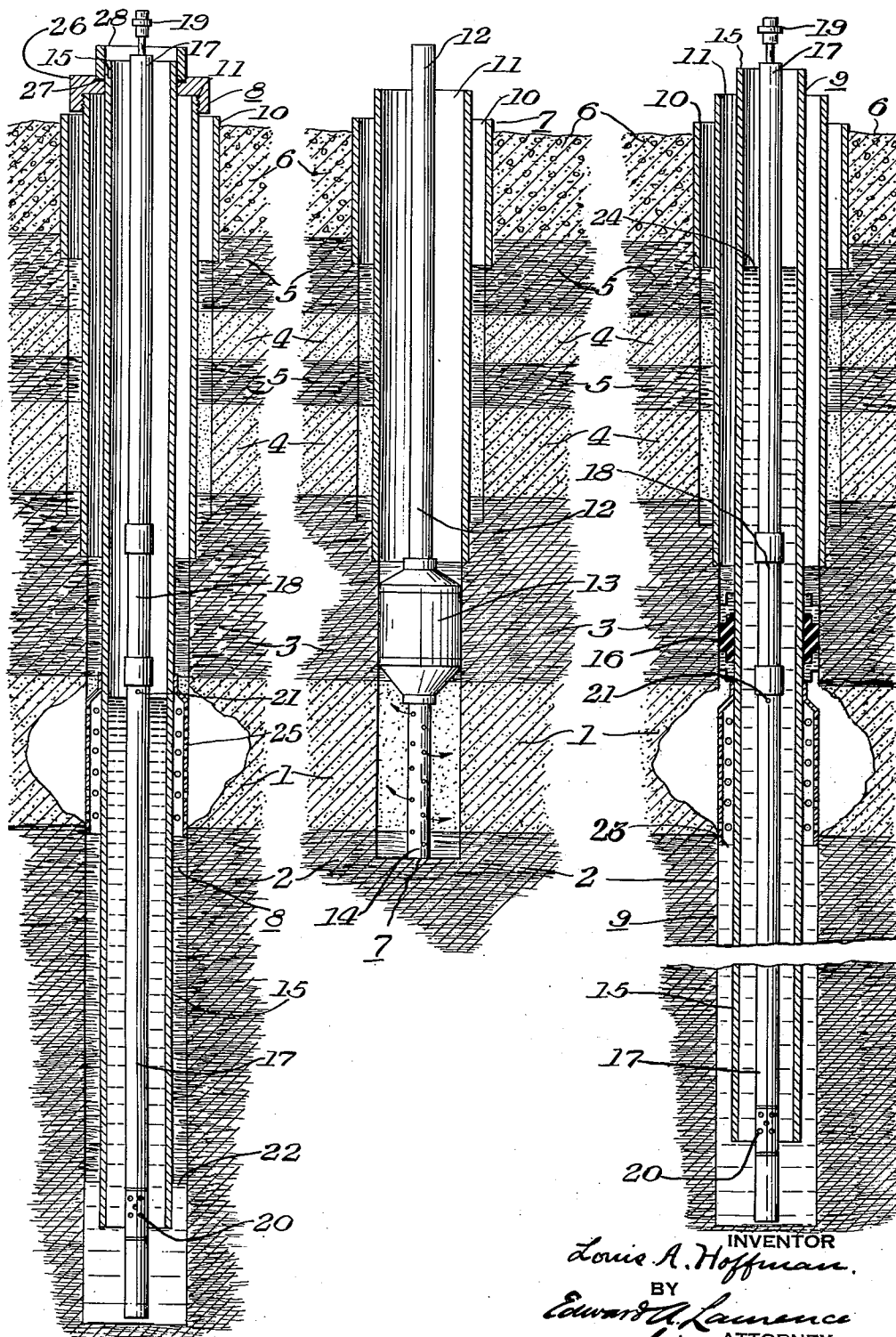
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EXTRACTION OF FLUIDS FROM THE EARTH

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EXTRACTION OF FLUIDS FROM THE EARTH

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2 Claims. (Cl. 166—2)

This invention relates generally to the extraction of fluids from the earth and more particularly to a method and apparatus to accomplish this purpose.

The method and apparatus which forms the subject matter of this invention may be advantageously applied to the extraction of oil from the earth through wells.

In extracting a liquid, such as oil, from a stratum in the earth the initial fluid pressure in the stratum is usually reduced or taken off, thereby producing the natural flow of the oil. Thus the initial stratum-pressure is depleted as the flow of oil is diminished. In order to extract additional oil from the sand stratum a series of wells having geometric relations are equipped with apparatus for repressuring the sand. Some wells are arranged to introduce a fluid under pressure into the stratum, and other wells surrounding the pressure well or wells are equipped as producing wells from which the oil is withdrawn to the surface. As in the case of the initial stratum pressure the repressuring fluid is gradually depleted. It may escape into adjacent strata or to the surface of the earth with the oil pumped from the producing wells; or it may be recirculated as by means of pumps and compressors.

The principal object of this invention is the provision of a method and apparatus for extracting liquids from the earth by maintaining and controlling the necessary fluid pressure on the yielding stratum.

Another object is the provision of a method and apparatus for extracting liquids from a stratum of the earth without loss of the natural fluid pressure within the stratum.

Another object is the provision of a method and apparatus for extracting liquids from a stratum by repressuring the stratum and retaining and controlling the repressuring fluid to recover liquids from the stratum.

Other objects and advantages appear from the following description and claims.

In the accompanying drawing a practical embodiment illustrating the principles of this invention is shown diagrammatically by a sectional view of a pressure well and two producing wells.

Referring to the drawing, the oil stratum 1 is confined between the relatively dense lower and upper strata 2 and 3 of slate, rock or similar character which is ordinarily impervious to the flow of fluids under a pressure exceeding the natural pressure of the stratum 1. The strata above the stratum 3 may consist of sand strata

4 and shale strata 5 and the earth or humus 6 at the surface.

The centrally disposed well 7 is a pressure well which is required when the natural fluid pressure in the stratum 1 has been depleted to repressure the stratum artificially. The wells 8 and 9, shown at either side of the pressure well 7, are producing wells. The location of these wells with respect to one another is determined principally by the manner in which the stratum 1 lies. It may be advisable to surround a pressure well with producing wells, and again it may be advisable to locate the pressure well on the edge or at one extremity of the sand stratum with the producing wells adjacent the other edge of the sand bed.

The pressure well 7, where such is required, and the producing wells 8 and 9 are provided with an outer casing 10 which extends down through the humus or surface strata, and where the strata above the strata 1 and 3 contain water, the wells are sealed off by means of an inner concentric casing 11 which extends down into the stratum 3 above the oil stratum.

The casing 11 may extend down past the oil bearing stratum, but in such case the portion of the casing extending through the stratum 1 is provided with openings or perforations for the admission of oil from the stratum to the interior of the casing 11. In the event that the stratum 2, which lies below the oil bearing stratum, is not firm and has a tendency to cave into the well, then the casing 11 should extend to the bottom of the well to keep it clean. This may be accomplished by underreaming the well hole and permitting the casing to closely follow the reaming tool until it reaches a firm strata or rests on the bottom of the well hole. This practice may be necessary in some localities, especially in the western fields.

In the case of the pressure well 7, a pressure tube 12 extends down through inner casing 11, and 13 is a packing sealing off the pressure tube in the well. If preferred the packing 13 may be interposed between the casing 11 and the tube 12. The lower end of the tube 12 extends down into the portion of the well hole which extends through the oil stratum 1. Fluid under pressure such as gas or air, is introduced through the tube 12 and out through its perforated lower end or cage 14, thus building up the predetermined pressure in the oil containing stratum.

As stated, in case the natural pressure in the oil bearing sand has not been dissipated or too greatly depleted, the pressure well is not required inasmuch as the pressure well is employed to re-

store dissipated or materially depleted pressure in the stratum.

Turning now to the producing wells indicated at 8 and 9, the said wells are drilled through and down past the oil stratum 1, care being taken to avoid unnecessary loss, dissipation or depletion of the existing pressure in the stratum during the drilling and casing operations.

An inner casing 15 is lowered into the producing well until its open lower end is adjacent the well bottom. This lower end of the casing 15 is preferably spaced a few feet from the bottom of the well to prevent disturbance of the sediment which may accumulate therein. Again the casing 15 may rest on the bottom of the well and have its walls perforated a few feet thereabove. The casing 15 is supported by any convenient means, such as the casing head or by anchors. The upper end of the casing 15 is vented to atmosphere to prevent back pressure.

25 represents a sleeve of greater diameter than the casing 15 but slidable down through the casing 11. The sleeve is mounted on the casing 15 and registers with the stratum 1 for the full extent of the latter, and the wall of the sleeve is perforated to allow the liquid to flow from the stratum to the well hole while preventing entrance of particles of rock or other material which would tend to clog the well hole. To hold the sleeve 25 in proper position on the casing 15 it may be secured thereto as by crimping in the upper end of the sleeve to snugly fit the casing and welding the joint, or the sleeve may be supported from the casing by a spider or spiders.

A packer 16 is employed to seal off between the casing 15 and the well above the oil bearing stratum 1 or between the casings 11 and 15 if the former extends to the bottom of the well. The character and operations of the packers 13 and 16 do not form a part of this invention and are therefore not described in detail but they must function to prevent the passage of fluid under pressure in either direction.

The seal between the casing 11 or the well hole and the casing 15 may be placed at the casing head, as shown in well 8, if there is no danger of escape of the fluid pressure from the well hole between the casing head and the oil bearing stratum. Thus a casing head 26 is provided with a lower threaded bore arranged to be screwed onto the top of the casing 11 and seal therewith. The upper bore of the casing head 26 snugly fits the perimetral surface of the casing 15 and is provided with a recess for receiving the packing 27. The ring 28 has a threaded bore to receive the upper end of the casing 15. After the proper length of the casing 15 has been determined and the ring 28 is screwed thereon, it may be lowered into the well until the bottom edge of the ring engages the packing 27 and is supported thereon and thus provides a seal between the casings 11 and 15.

A tubing string 17 suspended within the casing 15 extends from the top to the bottom of the well. A pump barrel 18 in the tubing string intermediate of its ends is provided with the usual standing valve at the lower end thereof, and the pump is operated by the sucker rod line 19. The lower end of the tubing string 17 is provided with a perforated boot or strainer 20 through which the liquid flows when the pump is operated. The ordinary foot valve is carried by the tubing above the strainer and a closed end anchor pipe may be secured on the bottom of the strainer in the usual manner. The relative position of

the strainer 20 is not vital to the operation of this invention but it is preferable to locate it sufficiently above the bottom of the well and within the casing 15 in order that it may pump the liquids of heavier specific gravity from the bottom of the well and not disturb and suck the loose sand.

A hole 21 in the wall of the tubing 17 is preferably placed immediately below the standing valve of the pump barrel 18. This hole may be as small as one-eighth inch in diameter. The hole is one of the controlling factors of this invention. Another factor is the distance between this hole and the lower end of the casing 15. To function properly the hole 21 in the tubing 17 must always be above the lower end of the casing 15.

It is obvious that the tubing 17 may extend down on the outside of the casing 15, but in such case it must be connected by a close passage with the interior of the casing 15 at the proper elevation, which passage would function as the hole 21 in the drawing.

Two other important factors are the fluid pressure of the strata and the specific gravity of the liquid being extracted.

In most instances an oil bearing sand, which in this case is assumed to be the sand stratum 1, contains a natural pressure. This pressure may be high or low. If the natural pressure is materially depleted and it is necessary to induce an artificial pressure in the strata, it is not considered good practice to charge the stratum with a pressure materially higher than the original natural pressure, as otherwise the pressure fluid may leak or find its way to another stratum, which would not occur if the artificial pressure were substantially the same as the natural pressure.

The specific gravity of the oils of a paraffin base such as are found in Pennsylvania, Ohio, and other adjoining states may vary from 0.7901 to 0.8861. The specific gravity of the asphalt base oils found in the West vary from 0.8875 to 0.9745. The lightest asphalt base oil is about as heavy as the heaviest paraffin base oil, and the average specific gravity of petroleum is approximately .8823. A one hundred foot column of water will produce a pressure of 43.35 pounds per square inch at 5° C., and the same column of oil having the average specific gravity, .8823, will produce a pressure of approximately 38.2 pounds per square inch.

To simplify the explanation it may be assumed that the pressure in the oil sand stratum is 38.2 pounds per square inch and this pressure was the original natural pressure of the stratum. Whether it now exists as a natural or artificial pressure is not important.

It will be noted that the producing wells are drilled deeper than the sand stratum 1. The depth they may be drilled below the sand is a practical consideration, depending upon the cost of drilling, the character of the strata, the requirement of casing, and the productive quantity and quality of the oil in the stratum 1. Assuming that these wells extend a little over one hundred feet below the stratum 1, the casing 15 should then extend to a point just below the strainer 20 which is itself a few feet above the bottom of the well. Under these conditions the hole 21 should then be approximately one hundred feet from the bottom of the casing 15. The axiom is that the pressure head produced by a column of liquid in the well between the bottom of the casing 15 and the hole 21, should not be

less than sufficient to balance the fluid pressure in the stratum 1.

Since the producing wells extend considerably below the sand stratum 1 the oil flowing from the sand will fill up the well outside and inside of the casing 15 and inside of the tubing 17. If there was no pressure in the stratum 1 the oil in the casing 15 being a liquid would seek its own level within the well. However where a pressure of 38.2 pounds per square inch within the sand stratum is assumed, the column of oil within the casing 15 will rise approximately one hundred feet above the sand stratum 1 as illustrated in the case of the producing well 9. The casing 15 is vented at the casing head so the air is not compressed by the oil rising therein.

If the sand stratum 1 were only one hundred feet in the earth or if the pressure were sufficiently high the oil may then flow from the casing 15. If this is not the case then it must be pumped.

As the oil is being pumped from the well, and it is not replenished from the sand as fast as it is pumped, the oil level on both sides of the casing 15 is lowered until it appears as shown in the case of the well 8 on the drawing. Here the level of the oil outside of the casing 15 as indicated at 22 is above the bottom edge of the casing and the level of the oil inside the casing 15 is just below the hole 21.

When pumping oil from a well, as the well 8, the level of the oil in the casing falls until it exposes the hole 21 to air, the pump ceases to pump oil and pumps air. The pressure in the stratum 1 being only 38.2 pounds per square inch cannot force the oil from the level 22 down around the bottom of the casing 15 since it is opposed by the head pressure developed by the column of oil inside of the casing between the level of the surface 22 and the hole 21, which head pressure is equal to or greater than the stratum pressure. Thus the fluid pressure is retained within the stratum and only that amount of oil which was above the hole 21 within the casing 15 and that above the surface 22 outside of the casing 15 has been removed. As stated above, if this particular well could not produce as fast as it could be pumped, then it is necessary to pump it only periodically, which period would be determined by the time required for the oil to rise to the level 23 which indicates the oil level in the stratum 1, in well 9 at which time the pressure balancing column of oil would extend from the hole 21 to the level 24 in the casing 15. The height of the column of oil between the hole 21 and the level 24 in well 9 is the same as the height of the column between the level 22 and the hole 21 in well 8. These columns are naturally the same vertical length because their head pressure balances the fluid pressure within the stratum 1. In other words, the pressure-balancing column is maintained at a constant length within the casing 15 and is measured from the level of the oil outside of the casing 15 regardless of whether this level is at 22 as in well 8 or 23 as in well 9, which are the limits of this oil level in this particular instance. This column is maintained at a constant length because it is produced by the pressure within the stratum. If this pressure should vary the length of the column would naturally vary in proportion to maintain a head pressure balance.

The level 23 of the oil in well 9 is shown to be adjacent the bottom of the oil bearing stratum. It is preferable to prevent this level from rising in the shot hole above the bottom of the stratum,

which it would naturally do if the well were permitted to stand for a sufficiently long interval of time between pumping operations. To prevent such rise the well should be pumped at sufficiently frequent intervals which are determined by the rate of flow of oil within the stratum. If the oil were permitted to rise to a material degree to the level of the oil in the stratum, then the latter would be dammed back and the flow of oil in the stratum toward the producing well would be intermittent instead of constant or even might be reversed toward another well.

The lower end of the casing 15 must extend below the oil bearing stratum 1 to permit the stratum pressure to establish a column of liquid within the casing 15 to provide a trap to prevent the depletion of the fluid pressure in the stratum.

The extension of the casing 15 below the stratum 1 determines the quantity of oil that may be extracted from the well during a pumping period if the well does not flow as rapidly as it can be pumped. If the lower end of the casing extends only a few feet below the stratum, the hole 21 in the tubing 17 is then placed above the lower end of the casing at a distance slightly greater than the length of a column of oil, the head pressure of which would balance the fluid pressure in the stratum 1. The length of the column in excess of that producing the exact balancing pressure is the factor of safety which should be maintained in the presence of varying pressure conditions in the stratum to avoid losing the fluid pressure therefrom. In well 8 the factor of safety is represented by the distance between the bottom of the casing 15 and the level 22. Thus when the casing 15 extends only a few feet below the oil bearing stratum only a correspondingly small quantity of oil can be pumped during a pumping period if the oil does not flow readily.

If on the other hand the oil flows as fast or faster than it may be pumped, then the pumping may be continuous without danger of loss of fluid pressure from the stratum and without the necessity of drilling the well materially deeper than the oil bearing stratum. Under these conditions my invention may be advantageously employed to prevent depletion of the natural pressure from the stratum.

Again the casing 15 may extend a considerable distance below the oil bearing stratum. This distance may be several times greater than the length of the balancing column. In such instances the hole 21 in the tubing 17 is placed above the bottom of the casing 15 at a distance slightly greater than the length of a column of oil, the head pressure of which would balance the fluid pressure of the stratum, in the same manner as described above. The oil available for pumping is that oil within the casing above the hole 21 and outside of the casing which is above the level 22.

Regardless of the depth of the well and the casing 15, the oil, if permitted to accumulate, will fill the space outside of the casing 15 and will cause the oil to rise inside the casing 15 to form a column above the oil bearing stratum, the pressure head of which is equal to the fluid pressure of the stratum.

In no instance should the hole 21 in the tubing 17 be lowered to reduce the effective length of the pressure balancing column or the fluid pressure will escape when the oil is pumped out of the casing 15.

The depth in the earth of the oil bearing stratum may be accurately determined if not known.

If the casing 15 is then lowered and packed off with the well hole then the oil will rise within the casing 15 to its maximum elevation as indicated at 24 in well 9. This position of the level 24 may be determined by measurement. Then the difference between the depth of the stratum 1 and the level 24 of the oil is the length of the pressure-balancing column. The specific gravity of the oil and length of the pressure-balancing column being known the fluid pressure in the oil bearing stratum can be determined and the tubing 17 lowered in the casing 15 to position the air vent hole 21 in the proper level relative to the lower end of the casing 15. The factor of safety to care for varying fluid pressure is also taken into account.

The positioning of the standing valve of the pump barrel just above the hole 21 in the casing 17 is, of course, only a preferable mechanical expediency.

As stated above, the advantage of placing the boot or strainer 20 adjacent the bottom of the well hole is only advantageous in enabling the pumping apparatus to extract liquids of greater specific gravity which may lie dormant in the bottom of the well hole. It is not necessary for the boot or strainer 20 to be at the bottom of an oil well if no water accumulates from the stratum. Thus the boot or strainer may be at any level below the pump barrel and if it be attached directly to the pump barrel 18, the foot valve and the hole 21 may be eliminated and the holes of the boot or strainer will serve in place of the hole 21.

Various modifications of the herein described method and structure of the apparatus and various applications of the same may be suggested to those skilled in the art, but it is understood that the invention is not limited to the preferred embodiment herein disclosed and various changes may be made within the scope of the following claims.

I claim:

1. In apparatus for extracting a liquid from a liquid-bearing stratum, the combination with a well hole extending through and to a point materially below the stratum, of an open ended casing within the well hole and extending from

a point materially below the stratum to a point above the stratum, the perimetral wall of said casing being spaced inwardly from the perimetral wall of the well hole, sealing means above the stratum extending from the outer perimetral wall of the casing to the perimetral wall of the well hole, a pipe extending down into the casing through which the liquid is withdrawn from the casing and from the space between the casing and the wall of the well hole below the stratum, and an open communication between the interior of the casing and the withdrawal pipe at a point at least below the top of the stratum and at a distance above the lower end of the casing proportionate to the length of a column of liquid within the casing capable of producing a pressure sufficient to balance the pressure at the face of the sand of the stratum to prevent depletion of fluid pressure within the stratum while permitting the free flow of liquid from the stratum.

2. In apparatus for extracting a liquid from a liquid-bearing stratum subjected to a fluid under pressure, the combination with a well hole extending through and to a point materially below the stratum, of a casing within the well and extending from a point materially below the stratum to a point above the stratum, said casing having its lower end open and vented at the top to the atmosphere, the perimetral wall of said casing being spaced inwardly from the perimetral wall of the well hole, sealing means above the stratum extending from the outer perimetral wall of the casing to the perimetral wall of the well hole, a liquid withdrawal tubing extending into the casing, a pump barrel carried by the tubing and arranged at the lower end thereof to admit liquid directly to the pump barrel from the casing at a point at least below the top of the stratum and at a distance above the lower end of the casing proportionate to the length of a column of liquid within the casing capable of producing a pressure sufficient to balance the pressure at the face of the sand of the stratum to prevent depletion of fluid pressure within the stratum while permitting the free flow of liquid from the stratum.

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