June 28, 1927.

1,634,235

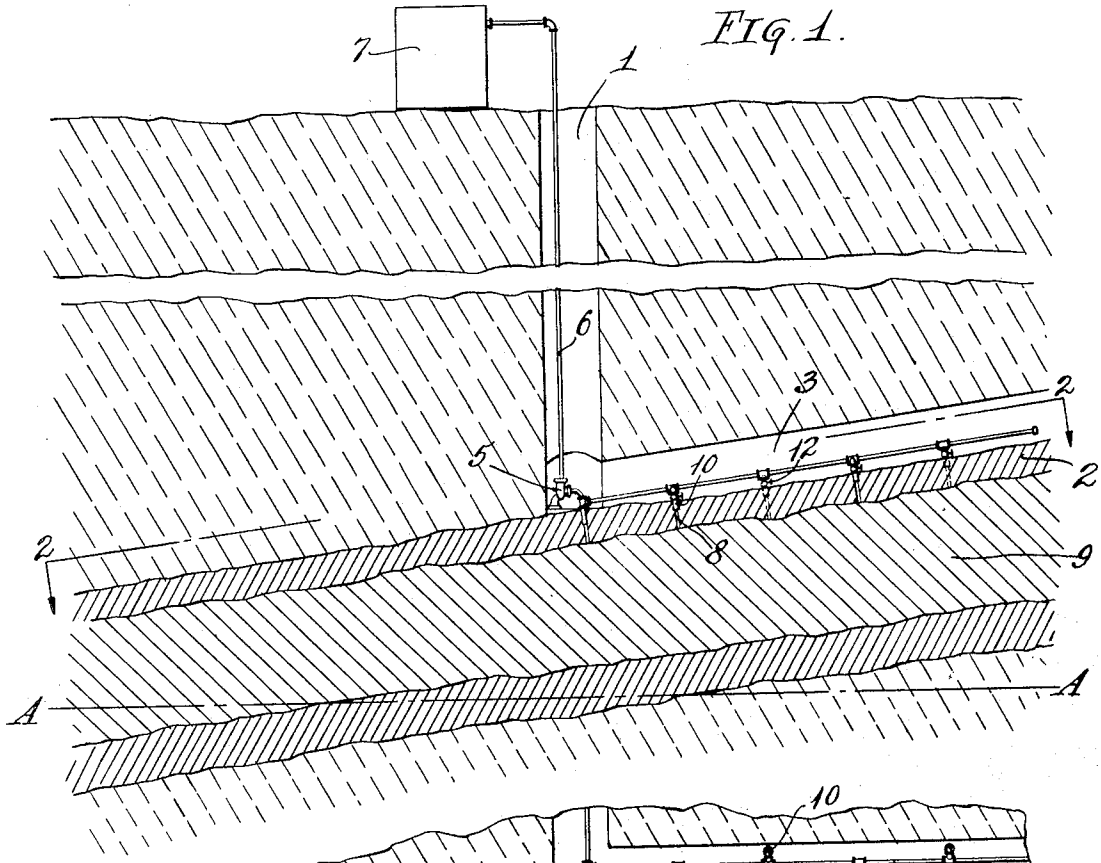
L. RANNEY

METHOD OF AND APPARATUS FOR RECOVERING OIL

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FIG. 1.



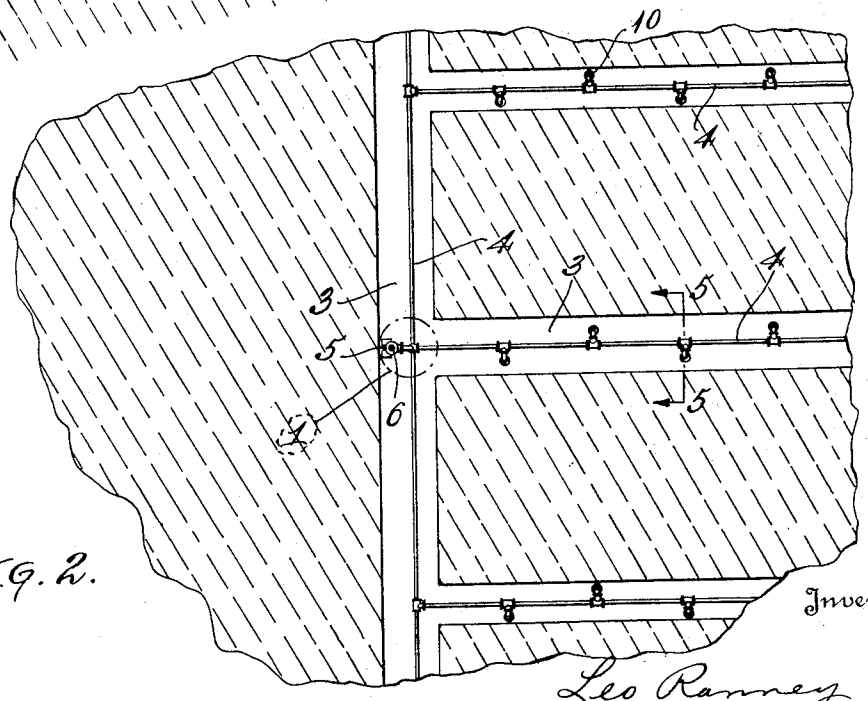


FIG. 2.

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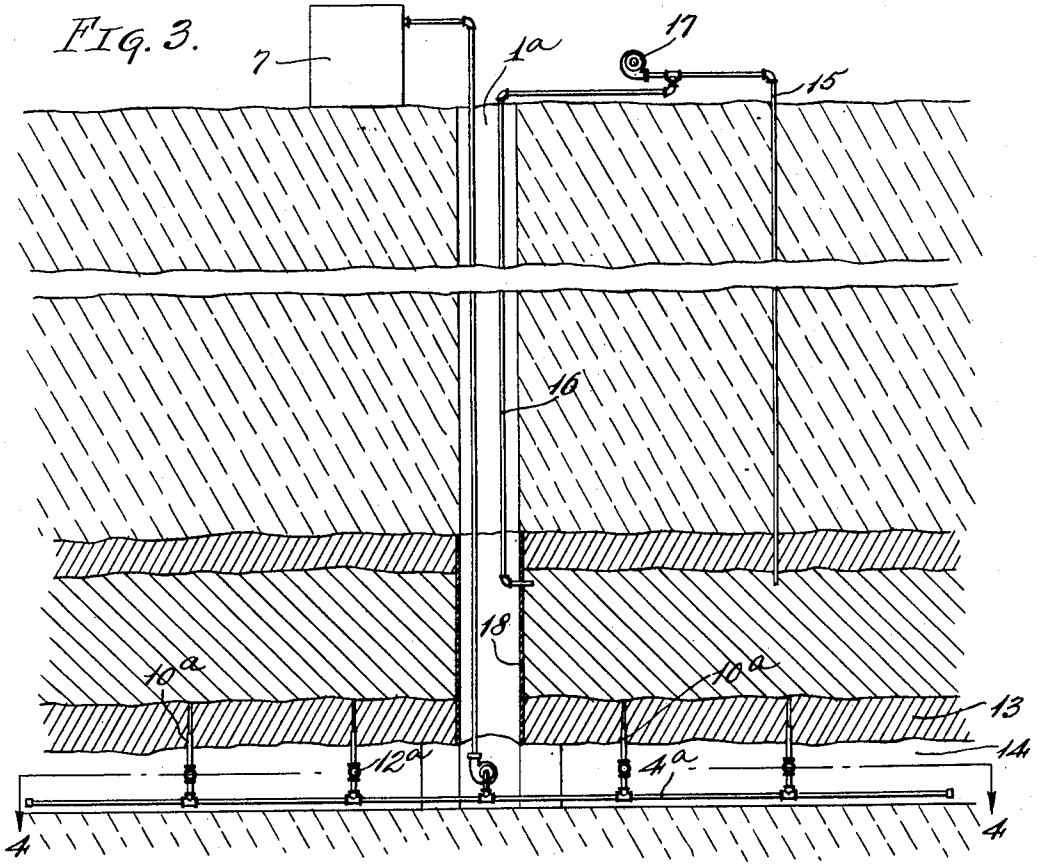
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FIG. 3.



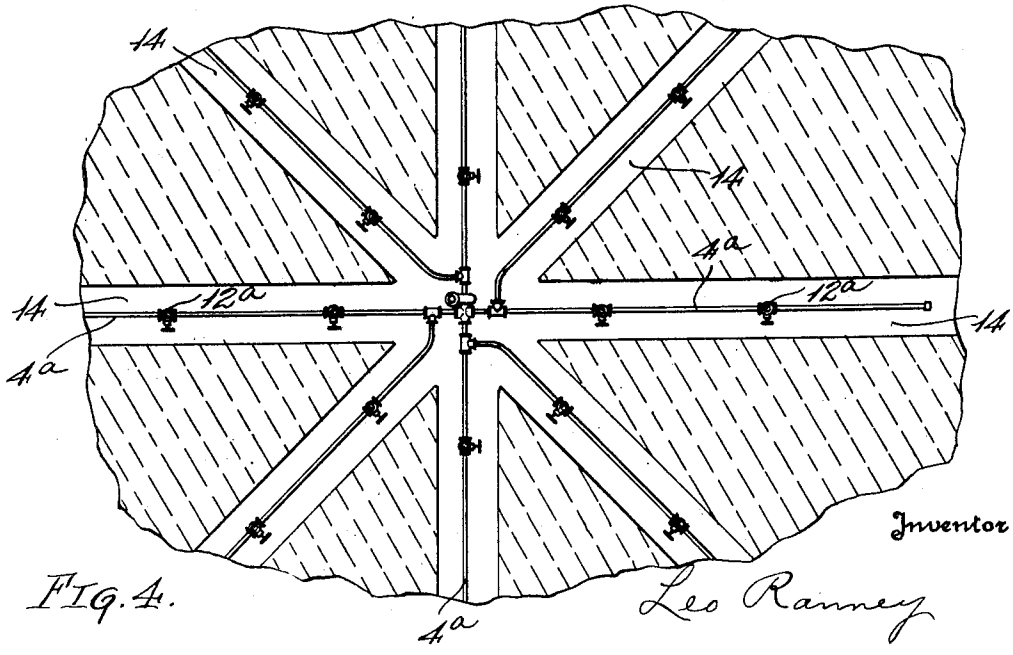


FIG. 4.

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METHOD OF AND APPARATUS FOR RECOVERING OIL

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FIG. 5.

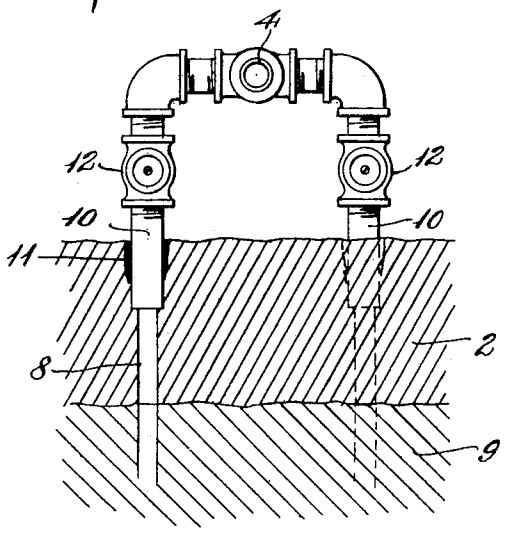


FIG. 6.

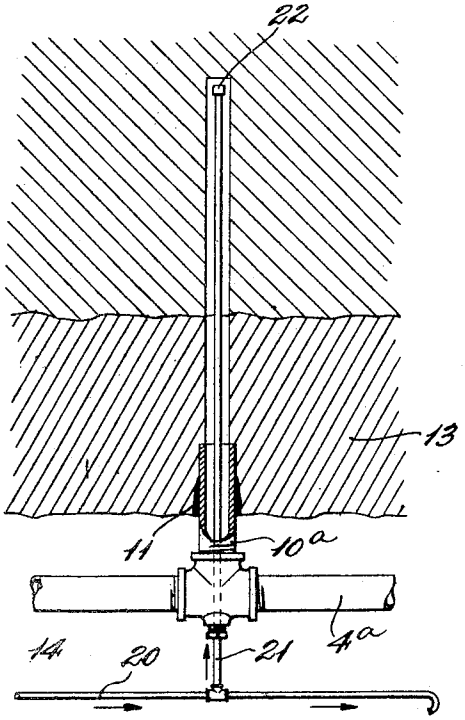
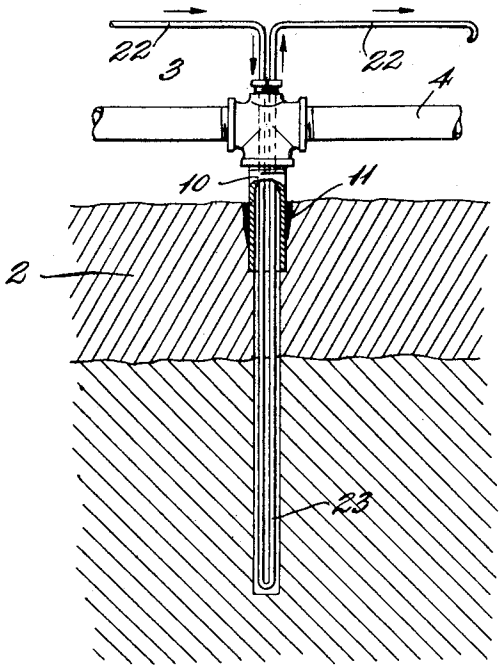


FIG. 7.



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UNITED STATES PATENT OFFICE.

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METHOD OF AND APPARATUS FOR RECOVERING OIL.

Application filed December 31, 1923. Serial No. 683,703.

This invention relates to the recovery of liquid natural products, such as oil, from the earth.

Mineral oil is recovered from more or less porous material, such as sand, sandstone, shale, limestone or the like, all commonly called sand, in which it has collected and is trapped or held by the characteristics and position of neighboring strata of the earth. The oil bearing sand is found at various depths and invariably lies beneath what is called the "cap rock", an essential characteristic of which is its impervious nature causing it to trap and confine beneath it in the porous sand oil, gas and sometimes water. Usually the oil sand lies above a similar impervious bedrock which has prevented penetration of the oil downwardly into other strata.

Experience shows that when the cap rock is punctured by a well tube the oil is caused to flow from said tube by the pressure of free gas which may have collected above the oil, but more important, by the continuing pressure of the gas absorbed or held in the oil or trapped in the pores of the sand, and the pressure of which is applied more and more to the oil as the latter is withdawn from the porous material in which it lies. Another force tending to cause flow of the oil to the surface is the hydrostatic pressure of water beneath it.

The usual method of oil recovery consists in sinking a plurality of wells (usually four to six inch casing pipes) to the cap rock above the oil bearing sand stratum, setting the casing upon the cap rock, and then drilling a smaller hole through the cap rock, and into the sand. Such wells are sunk at a number of separated locations in the field and from each one thereof are first collected the gas and oil caused to flow because of the pressure of the free gas or the gas absorbed in the oil or contained in the pores of the sand. When the flow diminishes the internal pressure is usually accentuated by the application to the well of a suction or vacuum pump. Recovery sometimes has also been increased in an abandoned, exhausted or dying field by application of air pressure introduced to the porous sand through one or more selected wells to increase the flow from other wells.

Notwithstanding all such methods it is the general opinion that the best methods of production in existing oil fields have not recovered more than from 10 to 40 per cent (more or less) of recoverable oil. Some investigators have estimated that if ordinary practice is followed the oil sands at practical exhaustion will contain as much as 8 or 10 times the quantity of oil recovered.

According to my invention the oil recoverable from most fields is increased considerably above what has been recovered by former methods and with a very marked decrease in the cost of production. The decrease in the cost is largely due to the fact that my method of recovering oil is largely in the nature of a mining method, doing away with the necessity for sinking a deep hole for each and every well, for a single shaft is sufficient to reach the oil bearing sands and the necessary pipes or holes to reach intimate contact with the oil bearing sand are of very materially reduced length and can be increased in number to any desired degree to cover a wide area at minimum cost.

The invention also enables air pressure, suction or vacuum or heating means, such as steam, to be economically or efficiently applied to a well or wells or to any desired portion of the oil bearing strata, and with more effective results, as will hereinafter appear.

The object of the invention is therefore to profitably recover oils for use which heretofore have not been considered recoverable with sufficient economy; to stimulate and increase the production of exhausted or dying fields; to conserve and hold imprisoned the supply of gas in the sand until the field is exhausted; to greatly increase the final percentage of recovery; and to reduce the total cost per barrel for the oil recovered.

Further objects of the invention are in part obvious and in part will appear more in detail hereinafter.

In the drawings, Fig. 1 represents a sectional elevation illustrating one embodiment of the invention; Fig. 2 is a sectional plan view on the line 2—2, Fig. 1; Fig. 3 is a view similar to Fig. 1 and illustrating another embodiment of the invention; Fig. 4 is a sectional plan view on the line 4—4, Fig. 3; Fig. 5 is a detail sectional view on the line 5—5, Fig. 2; Fig. 6 is a detail sectional view, somewhat diagrammatic, illustrating one ar-

rangement for utilizing heating means for accentuating the oil flow; Fig. 7 is a similar view illustrating still another arrangement for the same purpose.

According to my invention the first step in installing a proper system for recovering oil consists in sinking a shaft 1 from the surface of the earth through the over-lying strata to the region of the oil bearing porous material, such as sand, sand stone or the like. The depth of the oil bearing sands varies, but in any event the shaft is sunk according to usual methods of mining to a level adjacent the porous sands, either above or below the same. In the arrangement shown in Fig. 1 this shaft terminates above the cap rock 2. From the bottom of the shaft lateral tunnels or mine galleries 3 are dug out by usual mining operations along the plane of the impervious stratum. These lateral tunnels may extend in any direction, but where the oil bearing stratum and more particularly the cap rock lies on an incline, as in Fig. 1, the lateral tunnels may be run out horizontally or up the dip. It is not usually desirable to run the tunnels down the dip, due to the desirability of utilizing gravity to the fullest extent in draining the oil issuing from the porous formation. As will be readily understood the tunnels 3 may be arranged in any desired manner with side galleries or rooms so as to honeycomb the stratum above the cap rock and cover as wide a field or area as is necessary or desiarble. Through the tunnels and galleries 3 are led a series of interconnected pipe lines 4 all communicating with a suitable pump or pumps 5 discharging through a pipe 6 into a reservoir 7 preferably above the ground. The pipe system 4 is provided to lead the oil to the pump for carrying it to the surface of the ground and said system is therefore provided with the necessary collectors or branch pipes into which the oil flows from the oil bearing sands. These collectors are suitably spaced apart (usually at relatively short intervals as compared with the separation above ground of normal oil wells) and are formed by boring an opening 8 through the cap rock and extending it a suitable short distance into the oil bearing stratum 9. To conserve the oil, avoid leakage and maintain clean and sanitary tunnels the holes 8 are preferably sealed by introducing thereinto a short nipple 10, which is packed tightly on its outer surface by a suitable packer, as at 11, to prevent leakage of oil or gas between the nipple and the bed rock material. This packer may be of any suitable form, of material unaffected by oil, and is inserted in any suitable manner. Each nipple 10 is directly connected to the pipe system 4, preferably by way of a suitable valve 12. It is desirable to drill part way through the cap rock and seal in the nipple, as shown in the drawings, and then drill through into the sand. When the opening into the sand is completed, the nipple is connected with the oil collecting system.

With the arrangement described oil flows from the oil bearing sands to and through each of the collecting pipes 10 and thence through the pipe system 4 to be lifted to the reservoir 7 by the pump or pumps 5. Production is unusually economical due to the ability to tap a given field at a large number of relatively close points or zones at minimum cost. Therefore, the flow from each collector or branch pipe may be so slow that it would be commercially valueless if it issued from a well at the ground surface, but the total oil collected from a large number of such branch pipes in this system justifies the cost of installation.

The method and apparatus therefore are suitable for use in recovering oils that otherwise are left untouched. Flow of the oil into the collectors and pumping system is produced by all of the usual natural causes as in ordinary oil recovery practice. For example, in the arrangement shown, where the tunnels and piping system are above the cap rock, the first flow of oil is usually produced by the pressure of the gas trapped above or in the oil bearing sands or by internal pressure of the gas absorbed in the oil. Oil flow may also be produced by the hydrostatic pressure of water beneath the oil field, the water line being indicated at A—A. Obviously, as the water line rises, and especially where the cap rock is inclined, as shown, the several branch collectors 10 will one by one be killed, but may readily be shut off at their respective valves 12 to avoid contamination of the product by water. The field will, therefore, produce to the limit of the area covered or until all collectors are killed, the sealed nipples and cap rock obviously preventing water from entering the tunnel system.

In some instances the oil flow may be produced or increased by artificial supply of water beneath the oil bearing sands, as has occurred in the Bradford field of Pennsylvania, although water floating in most instances is considered dangerous for other reasons. In addition oil flow may be increased by a pumping effect, either by a special form of pump 5 producing a suction effect throughout the piping system or by the use of one or more suction pumps producing an effective vacuum or suction at the collecting pipes 10, the oil thereby collected being raised to the surface of the ground by additional pumps if necessary. Where dangerous gases are found above the oil in the same sand, the main shaft may be sunk outside of and near the edge of the structure, avoiding gas entirely.

Fig. 3 shows another arrangement in

which the main shaft 1^a is sunk clear through the oil bearing stratum to a level beneath the bed rock 13, at which level lateral tunnels and galleries 14 are run beneath the bed rock, as before. The piping system 4^a in this case is again extended through the tunnels and the oil bearing sands are tapped by openings of suitable size distributed through the tunnels and galleries with nipples 10^a therein, each connected to the piping system by its valve 12^a.

With this arrangement the oil flow is producing or accelerated by gravity in addition to such internal gas pressure as may be present or remain but, if gravity and gas pressure are insufficient, positive air pressure may be supplied to the oil bearing stratum either through a pipe 15 from the surface of the ground or by a pipe 16 run down the shaft 1^a and thence into the oil bearing sand, or both, such pipes being connected to an air pressure pump 17. Obviously, the wall of the shaft must be sealed or closed where it pierces the oil bearing sands, such as by a casing or jacket 18, thereby avoiding free flow of oil into the shaft or escape into the shaft of gas or air pressure existing or produced by artificial means.

When suction or vacuum is applied to increase the production of a field, either initially, due either to absence of gas pressure or high viscosity of the oil which retards its flow, or later on to a dying field it is obviously more economical and efficient in the present arrangement than in prior practice, due to the ability to locate the suction or vacuum pump or device at a level either closely approximating that of the oil bearing sands or, at least, within barometric distance above the same. A higher degree of vacuum is therefore available with less reduction from losses in the line and with the ability to utilize vacuum where it would otherwise be ineffective.

Air pressure applied to the field by my system is also more effective because its effects are not diminished or, indeed, are accentuated by coarse or ultra-porous partings or streaks in the oil sand. Such partings or streaks are those from which the oil is first exhausted and according to the present practice in supplying air pressure to a field afford convenient by-passes by which the air pressure is readily dispatched to remote regions of the field with loss of effectiveness. This result is due to the attempt in prior practice to utilize the air pressure to positively drive or lift the oil to the pipe line level. However, in my method the oil is delivered to a pipe line or system located at approximately the level of the oil sand and conveniently may be beneath the same. Consequently the air pressure may be applied to the field to assist gravity in driving the oil downwardly and porous streaks or partings in the oil sands merely distribute the pressure and make it more effective over the entire field.

Figs. 6 and 7 illustrate, somewhat diagrammatically, arrangements for utilizing the effect of heat to increase oil production. For example, in Fig. 6 the horizontal tunnel 14 communicating with the main shaft is located below the lower cap rock or bedrock, as in Fig. 3. The oil pipe line or system 4^a has branches 10^a passing upwardly through the bedrock into the oil field. In this system there will also be provided a steam pipe line 20 having branches 21, one for each of the collecting pipes 10^a and passing longitudinally through the same, as shown in the drawings. Such pipes may be capped at their ends, as at 22, and merely form heaters or radiators for supplying the heat of the steam to the collecting pipe and neighboring portions of the oil bearing sand. The sand adjacent to the collecting pipe is therefore kept hot and paraffin or like products will not condense or solidify adjacent the oil inlet pipe and thereby clog or prevent flow of oil thereto, or the paraffin will be kept liquid and flow with other oil fractions into the oil system. In Fig. 7 the tunnel 3 is above the cap rock 2 and the steam heating pipe 22′ has a return bend 23 passing into the branch collector 10 of the oil line or system 4. Steam may therefore be circulated through a return bend with an increased heating effect.

These heating arrangements avoid any necessity for drawing the tubing and placing a small shot in the well to loosen the paraffin. Such shots are a mere temporary benefit and in the end force the paraffin into the pores, clogging them and decreasing or stopping the flow of oil.

My heating system also avoids both contamination of the oil or oil field by water or moisture condensed from the steam because the steam is never brought into actual contact with the oil sand.

The method and apparatus described are particularly suitable for use in the recovery of heavy oils relatively free from gasoline, naphtha, kerosene and other like light fractions. Indeed, the method has been used for recovering oil so heavy that it is not recoverable by ordinary methods, due largely to its high viscosity and to the capillary action in the sand and the adhesion of oil to the grains thereof. However, it is also useful in the recovery of lighter oils, especially where gas is not present or is in quantities so low as to avoid danger. In any event the tunnels and shaft are sealed from the oil bearing stratum and oil and gas are not allowed to find their way thereinto and are clean and safely habitable for workmen.

The complete system is under exact control, far more so than the individual widely

distributed wells of the ordinary oil field. For this reason the recovery of oil is largely increased by my process from a field underlain by water, where the hydrostatic pressure is utilized for raising oil to the pipe line level. Under such conditions careful observation of each individual branch pipe or collector enables it to be shut off as soon as the cone of water beneath it has produced water flow, allowing the several individual small water cones to recede and to be followed by another oil producing period.

Other advantages will be apparent to those skilled in the art to which the invention relates. In my copending application Serial No. 14,448, filed March 10, 1925, I have claimed the sealing and heating methods and equipment described in the present application.

What I claim is:

1. Process of recovering oil from an oil bearing stratum, and comprising forming a tunnel near the stratum but spaced therefrom by material substantially impervious to fluid, providing a plurality of communications between the oil bearing stratum and a fluid-conducting system in the tunnel and regulating production by selectively controlling flow through a plurality of the communications, said regulation being effected near the oil bearing stratum.

2. Process of recovering oil from an oil bearing stratum, and comprising forming a tunnel generally parallel to the plane of the oil bearing stratum but spaced therefrom by a stratum substantially impervious to fluid, providing relatively closely spaced communications between the oil bearing stratum and conducting pipes in the tunnel, and individually and selectively controlling a simultaneous delivery from a plurality of said communications, said control being effected near the oil bearing stratum.

3. Process of recovering oil from an oil bearing stratum containing fluids other than oil, said process comprising sinking a mine shaft to a point adjacent the oil bearing stratum, tunneling near the oil bearing stratum but separated therefrom by a stratum substantially impervious to fluid, forming a plurality of relatively closely spaced small openings to afford communication between the oil bearing stratum and conducting pipes in the tunnel, and restricting flow from such of said openings as tend to discharge fluids other than oil, whereby opportunity is given for such other fluids to recede and be replaced by recoverable oil, said restriction being effected near the oil bearing stratum.

4. An installation for recovering oil, or the like, from an oil bearing stratum, and comprising a tunnel adjacent said stratum, but spaced therefrom by material substantially impervious to fluids, a collecting pipe in said tunnel, a plurality of nipples connected to said collecting pipe and sealed in said impervious material, said nipples leading from mine wells formed in the oil-bearing stratum, and each discharging into the collecting pipe and a valve on each nipple, whereby the flow therethrough may be individually and selectively controlled near the oil bearing stratum to regulate the discharge of fluid.

In testimony whereof I hereby affix my signature.

LEO RANNEY.