July 30, 1929. L. RANNEY 1,722,679

PRESSURE METHOD OF WORKING OIL SANDS

Filed May 11, 1927 3 Sheets-Sheet 1

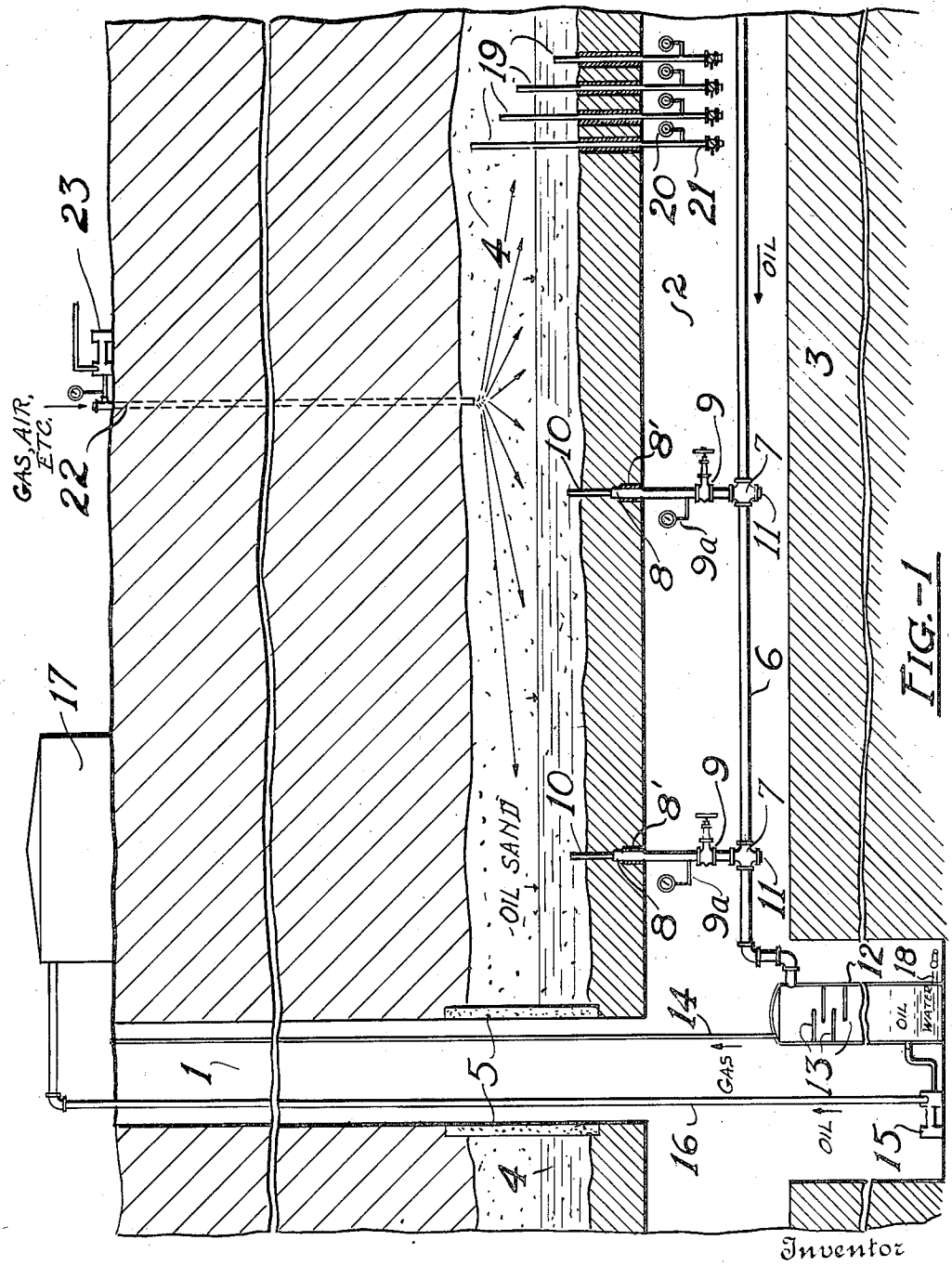


FIG. -1

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PRESSURE METHOD OF WORKING OIL SANDS

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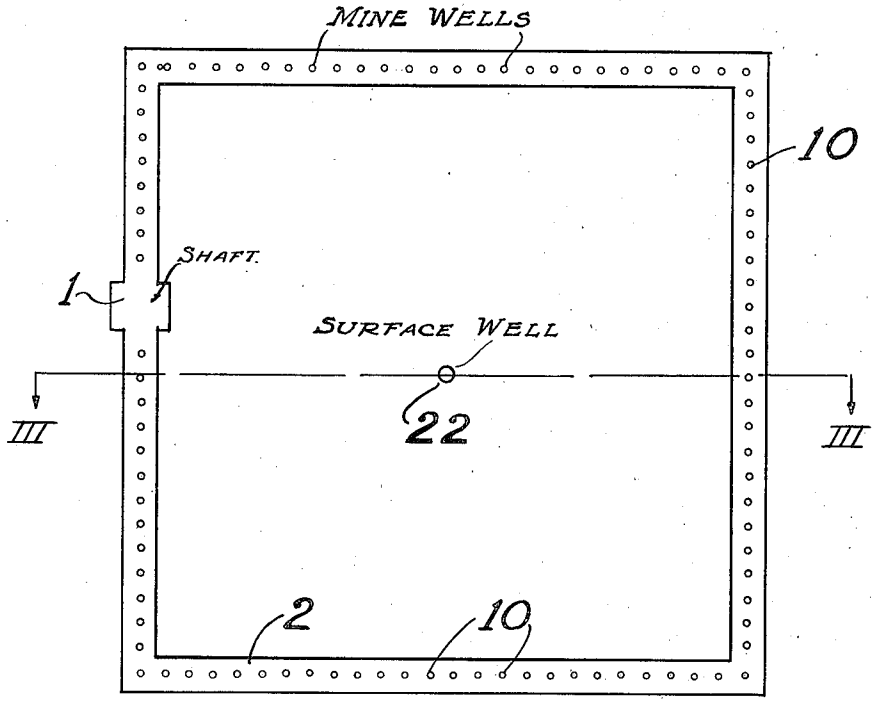


FIG.-2

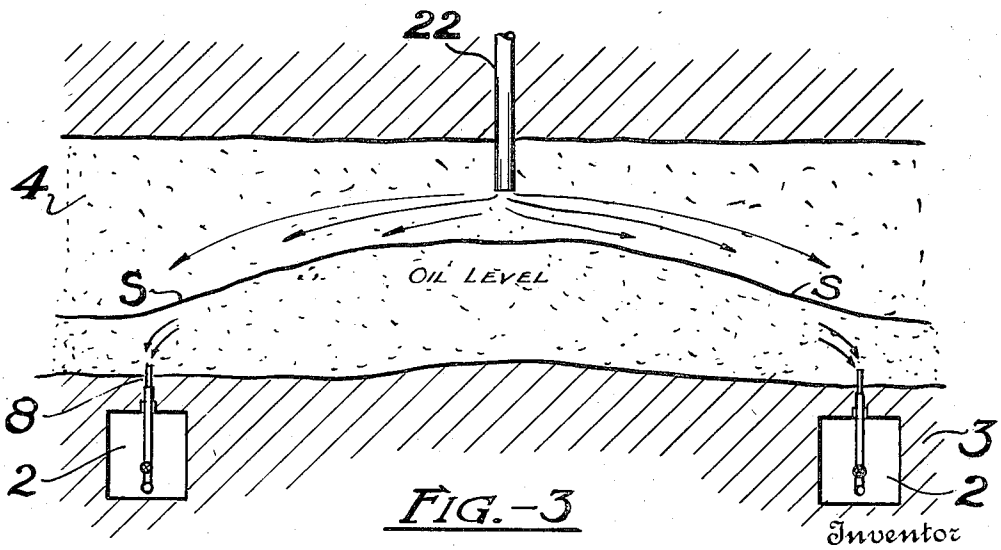


FIG.-3

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PRESSURE METHOD OF WORKING OIL SANDS

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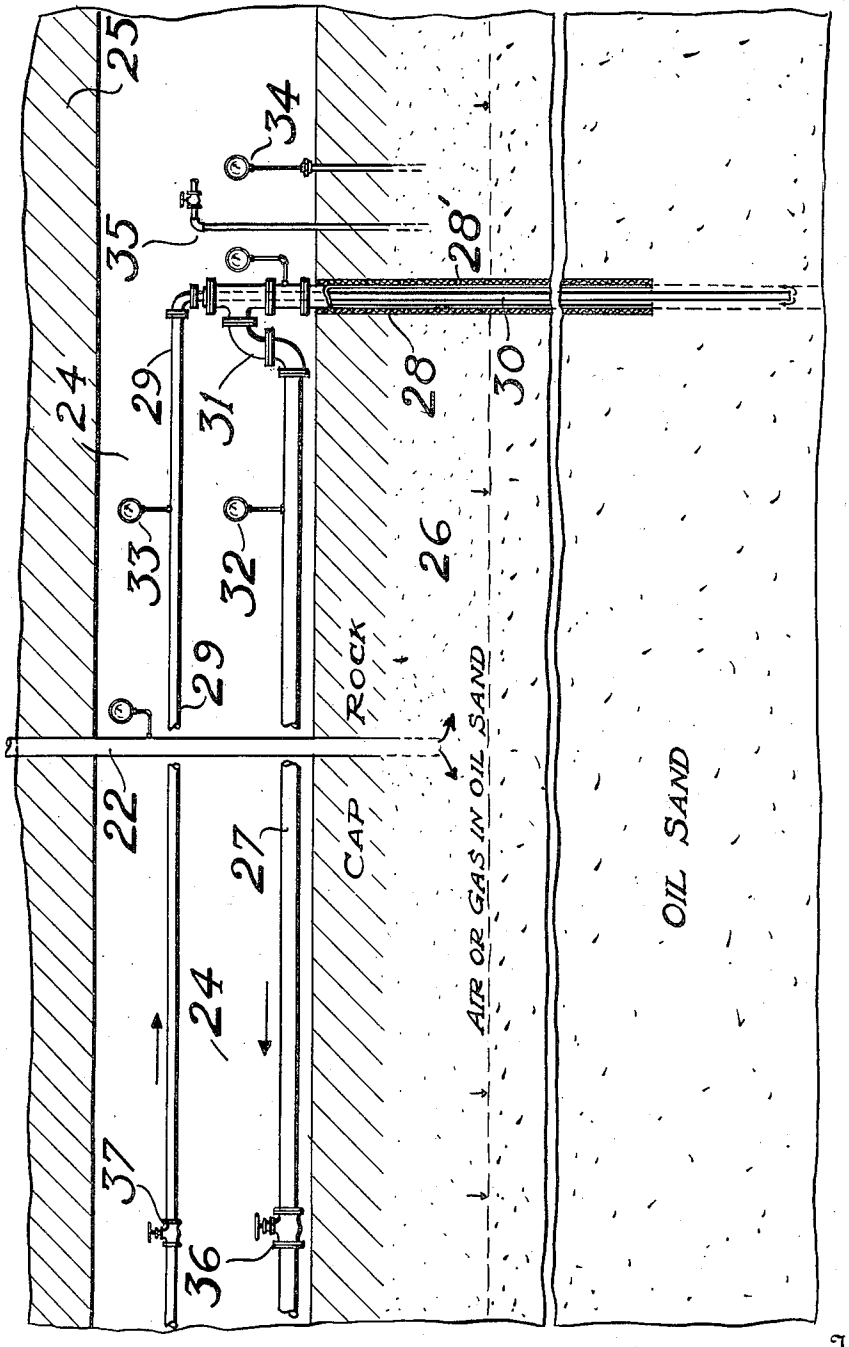


FIG.-4

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UNITED STATES PATENT OFFICE.

LEO RANNEY, OF NEW YORK, N. Y., ASSIGNOR TO STANDARD OIL DEVELOPMENT COMPANY, A CORPORATION OF DELAWARE.

PRESSURE METHOD OF WORKING OIL SANDS.

Application filed May 11, 1927. Serial No. 190,393.

This invention relates to improvements in the recovery of oil from the earth by mining methods of the type described and claimed in my United States Patents Nos. 1,634,235 and 1,634,236, granted June 28, 1927, and in my copending application Serial No. 100,531, filed April 8, 1926.

In the method described in those patents and application, a mine gallery is driven adjacent the oil sand but spaced therefrom by material substantially impervious to fluid. The gallery may be above or below the sand. Holes forming "mine wells" are drilled from the gallery into the oil sand. Nipples sealed in the mine wells receive the oil or other fluid and discharge it into collecting pipes. Valves are provided on each nipple for the control of flow.

The invention will be fully understood from the following description read in connection with the accompanying drawings, in which

Fig. 1 is a diagrammatic vertical section through an installation embodying the invention;

Fig. 2 is a diagrammatic transverse section showing an arrangement of the mine wells about the producing area;

Fig. 3 is a vertical section on the line III—III, Fig. 2; and

Fig. 4 is a diagrammatic vertical section showing air or gas lift means.

Referring first to Figs. 1 and 2, reference numeral 1 denotes a mine shaft opening into a mine gallery 2. This gallery is formed in a lower cap rock 3 underlying an oil sand 4. The shaft 1 is surrounded by a concrete wall 5, or the like, where it passes through the oil sand. A collecting pipe 6 is installed in the gallery 2 and is connected by cross fittings 7 to a large number of closely spaced nipples 8. These nipples are sealed in the cap rock, as at 8'. They are directed toward the oil sand but do not enter it, unless it is necessary to have the nipples extend above the level of any water that may be in the bottom of the sand. A gate valve 9 and pressure gage 9^a are provided on each nipple.

A hole 10 is drilled from the end of each nipple into the oil sand, forming mine wells. The procedure, as described in my patents and application mentioned above, is to seal the nipple in place, remove a plug 11 on the bottom arm of the cross fitting 7, insert the drill through a stuffing box (not shown) attached at the lower end of the cross fitting, open the gate valve, insert the drill through the nipple and through the open gate valve, and drill into the sand. When this has been done, the drill is drawn back past the gate valve, which is then closed. The drill and stuffing box can now be removed and the plug 11 replaced without danger of fluids escaping from the sand into the gallery.

The collecting pipe 6 discharges into a separator 12 in which baffle plates 13 are arranged. Gas is vented from the separator through a pipe 14. Oil is withdrawn by a pump 15 through a pipe 16 to an above-ground storage tank 17. A pipe 18 is provided for removing water that may collect in the lower part of the separator.

Test pipes 19 extend into the oil sand to a progressively increasing distance from the gallery. Each test pipe has a pressure gage 20, and a draw-off valve 21 for sampling the contents of the pipe. Thermometers or any other desired measuring or recording instruments may be connected to or inserted into the test pipes.

One or more wells 22 are drilled from the surface of the earth to the upper part of the oil sand. A compressor 23 is provided for forcing natural gas, natural gas saturated with gasoline vapor, air, or other oil-expelling fluid through these wells into the sand. In cases where the sand is of substantially uniform porosity throughout, I prefer to utilize one centrally located surface well 22, as shown in Fig. 2. When working a square tract of 40 acres, a gallery 2 may be driven completely around the tract with closely spaced mine wells formed from the gallery. There may be 132 of these mine wells on each side of the tract. A smaller number will do for very porous sands. Various other arrangements of the galleries, injection wells, and mine wells may be made.

The injected natural gas or other oil-expelling agent causes the oil to flow toward the mine wells located around the field. In the absence of gas pressure, oil does not flow as completely as is desirable to the collecting wells. Apparently, it is retained in the central part of the area at a higher level than at the edges, the surface of oil-saturated sand sloping from the center downward to the mine wells, as at S, Fig. 3. This may be referred to as the "angle of

repose" of oil in the sand. The injected gas tends to flatten this angle and in its radial movement from the intake well drives oil towards the mine wells.

In case there are dense portions of the sand, it may be necessary to distribute surface wells so as to avoid the blocking off of the injected gas. One or more surface wells may be drilled on each side of the dense portions, so that the injected gas may have access to all the sand.

The following example will show how the installation is operated: It will be understood that the present invention is designed primarily for recovering oil from those low pressure sands which are "exhausted" so far as surface well production is concerned, but which nevertheless contain much oil. An expulsive agent, for example natural gas, is forced into the central well 22 at a pressure of about 100 lbs. per square inch. This pressure gives adequate flow in oil sands of ordinary compactness. When a high rate of oil flow is desired, or when the sand is very dense, the pressure may be 200 lbs. or more per square inch. On the other hand, pressures as low as 20 lbs. per square inch are satisfactory for very porous sands and a medium rate of oil flow. The pressure is determined by natural and economic conditions.

The preferred procedure is to maintain a horizontal layer of oil-saturated sand, forming a barrier between the expulsive agent and any exit from the sand. This is an important feature of the invention. In surface well practice, gas injected into the sand is not fully effective. Both the gas intake wells and the oil producing wells extend through the entire body of sand, so that at any level in the intake wells there is an opening through any porous streaks in the sand to the same level in the producing wells. These porous streaks normally run horizontally, parallel to the body of sand, and serve as conduits for the gas, which accordingly escapes without exerting much pressure upon the oil. Such porous streaks, although filled with oil, do not constitute a barrier. The injected gas easily displaces the oil, since the movement is horizontal. Oil moves rather readily in this direction.

In my method the oil movement may be compelled transversely downward. Oil resists flow in this direction and furnishes an excellent surface for the application of the gas pressure. The impervious barrier of oil may be gradually forced down toward the collecting wells, with a very high recovery of oil. In addition to the protection against escape of gas afforded by the horizontal layer of sand filled with oil, a further protection is provided by maintaining periodically as required a column of oil in each nipple, above the valve but not high enough to obstruct the most effective flow of oil from the sand. This protective column of oil is maintained when there is a fissure or exceptionally porous area near the mine wells, or when the oil level in the sand has been lowered to a point near the mine wells. In case there is danger of gas blowing through the nipples or when gas has begun to blow through, the valves are closed down until only oil is produced. It will be understood that this blowing through of gas may be permitted to occur periodically for short intervals, with resulting temporary evacuation of the adjacent region in the sand, the valves then being regulated to check the escape of gas.

The pressure of the injected gas is regulated so as to control the tendency of the gas to break through at the mine wells. To this end I have provided groups of test pipes 19 at various places in the gallery. The pressure differential between the gas-filled space in the sand and the point of withdrawal of oil from the sand may be determined by consulting the pressure gages 9^a and 20 on the oil collecting nipples 8 and the test pipes 19, respectively. If the proper pressure differential is maintained, there will be a constant and regular flow of oil from the exposed sand in the mine wells, without the uncontrolled escape of the expulsive gas. For example, if in a sand of a certain porosity it is found that a differential of 5 lbs. is most effective for the expulsion of oil, this differential is maintained as closely as possible. If the differential becomes less than 5 lbs., the control valve 9 on the nipple 8 is slightly restricted, and if the differential becomes more than 5 lbs., the control valve is slightly released.

In Fig. 4 there is illustrated an alternative form of installation in which a gallery 24 is driven in a cap rock 25 overlying an oil sand 26. An oil collecting pipe 27 is laid in the gallery and is connected to a plurality of nipples 28, only one of which is shown. The nipple 28 is sealed in the cap rock by sealing material 28′ and extends downward to near the bottom of the sand. A gas or air line 29 is installed in the gallery and has a branch 30 passing through the nipple and beyond its lower end.

The gas pressure imposed on the sand through the surface well 22 cannot be economically used to raise the oil when the sand is of considerable thickness. In such a case the column of oil standing in the collecting nipple 28 may have sufficient hydrostatic head to exert an objectionable back pressure on the sand, preventing or retarding the flow of oil. When this occurs, gas is passed through the line 29 and branch 30. It will bubble up through the oil in the nipple, lightening it and causing it to overflow into the collecting pipe 27. To prevent the re-

turn of any oil to the nipple, an inverted goose neck 31 is formed at the joint where each nipple joins the collecting pipe 27. Oil may be raised in this way without objectionable back pressure on the sand. In the average case, an air lift can be operated in the manner described with the exertion of less than one atmosphere gauge pressure against the exposed face of the oil sand.

When the sand is not very thick, oil can be raised to the collecting system by the application of a small amount of pressure, without the aid of a gas lift. Thus the oil may not have to rise more than a few feet in nipple 30 (Fig. 4), before discharging into the collecting system 27. A pressure which would be quite incapable of forcing the oil to the surface of the earth will easily suffice to raise the oil to the collecting system.

Pressure gages 32 and 33 are provided on the pipes 27 and 29. A pressure gage 34 is also connected directly with the top of the sand so that the pressure in it may be ascertained. Samples of gas may be taken off for analysis through the valved pipe 35. Control valves 36 and 37 are arranged in pipes 27 and 29.

In some cases it may be desirable to utilize expulsive agents heavier than oil, such as water or acqueous salt solutions. Water, for example, can be run in through one or more surface wells to a point adjacent the bottom of the oil sand. Mine wells, formed from above the sand, as described in connection with Fig. 4, receive the oil forced upward by the water rising horizontally through the sand. In this mode of applying the invention there is a barrier of oil filled sand above the explusive agent; in the gas method previously described such a barrier is below the expulsive agent. The water, like the gas, can be controlled in its escape along any level through porous streaks to producing wells, and may be compelled to move across the oil bearing stratum.

An auxiliary barrier against escape of expulsive agent (air, gas, water, etc.) may be provided by maintaining a column of oil in each downwardly extending nipple 28, said column preferably being in contact with the valve in the nipple. The control valves in the nipples are adjusted to secure this result, the method being analogous to that described above for retaining oil in the upwardly extending nipples 8.

Various changes and alternative arrangements may be made within the scope of the appended claims, in which it is my intention to claim all novelty inherent in the invention as broadly as the prior art permits.

I claim:

1. In the recovery of oil from an oil bearing stratum by a mining method, the improvement which comprises forcing an oil expulsive agent into the stratum near an outside surface only, and withdrawing oil from points only opposite said surface, whereby the expulsive agent is compelled to move transversely across the stratum and to force the oil toward the points of withdrawal.

2. In the recovery of oil from an oil-bearing stratum by a mining method, the improvement which comprises forcing an oil expulsive agent into the stratum near an outside surface only, withdrawing oil from points only opposite said surface, whereby the expulsive agent is compelled to move transveresly across the stratum and to force the oil toward the points of withdrawal, and controlling the escape of the expulsive agent.

3. Method according to claim 2, in which gas escapes through the oil withdrawal lines and control means is then actuated to check the escape of gas.

4. In the recovery of oil from an oil bearing stratum by a mining method, the improvement which comprises forcing an oil expulsive agent into the upper part of said stratum, and withdrawing oil through outlets opening near the bottom only of the stratum, whereby the expulsive agent is compelled to move downward without loss against a barrier of oil.

5. Method according to claim 4, in which the pressures in the various areas of the oil-bearing stratum are determined, and the flow openings are controlled in accordance with the pressures to prevent the expulsive agent from breaking through at any of said openings.

6. In the recovery of oil from an oil sand by a mining method, the improvement which comprises forcing a gas into the sand near its upper surface, withdrawing oil from a plurality of points adjacent the bottom only of the sand, and so regulating the pressure and withdrawal of oil as to maintain at all times a barrier of oil-filled sand between the gas-filled area and the withdrawal openings.

7. In the recovery of oil from an oil sand by a mining method, the improvement which comprises forcing a gas into the sand near its upper surface, withdrawing oil from a plurality of closely spaced points adjacent the bottom only of the sand, determining the pressures prevailing in various areas of the sand, and regulating the pressure of the gas and the withdrawal of oil to maintain a proper pressure differential between the gas in the sand and at the exposed producing surface.

8. In the recovery of oil from an oil sand by a mining method, the improvement which comprises forming a plurality of openings around the area of sand to be worked, said openings being adapted for the withdrawal

of oil from near the bottom of the sand, forcing a gas into the sand near its upper surface and within said area, preventing escape of said gas, and withdrawing oil from said openings.

9. In the recovery of oil from an oil sand by a mining method, the improvement which comprises driving a gallery above the sand, said gallery being adjacent the sand but spaced therefrom by material impervious to fluids, drilling from the gallery to form a plurality of mine wells opening near the bottom of the sand, injecting a gas into the upper part of the sand to force the oil toward the mine wells, and applying fluid-lift means to raise the oil in said wells.

10. In the recovery of oil from an oil bearing stratum by a mining method, the improvement which comprises forcing an oil expulsive agent into the stratum near its upper surface only, forming a plurality of oil withdrawal openings in the lower part only of the stratum, seating valved nipples in said openings, and regulating the flow through the nipples to retain a sufficient column of oil above the valves therein to prevent passage of expulsive agent through the nipples.

11. In the recovery of oil from an oil bearing stratum by a mining method, the improvement which comprises forcing an expulsive agent into the stratum near its upper surface only, forming a large number of closely spaced oil withdrawal openings in the lower part only of the stratum, whereby the expulsive agent is compelled to move downwardly against a receding barrier of oil, seating valved nipples in said openings, and retaining a column of oil in any nipple above the valve therein when the expulsive agent approaches said nipple, whereby a further barrier to the escape of the expulsive agent is provided.

12. In the recovery of oil from an oil sand by a mining method, the improvement which comprises establishing a point of withdrawal of oil near the bottom of the oil sand, forcing a pressure medium into the upper part of the sand, and delivering said withdrawn oil at a short distance only above the sand into a collecting system whereby a medium of relatively low pressure is capable of lifting the oil into the collecting system.

13. An oil recovery installation comprising a mine gallery formed adjacent an oil sand but spaced therefrom by material substantially impervious to fluids, an oil collecting system in said gallery, pipes connecting the lower part only of the oil filled area of the sand with the collecting system, control valves on said pipes, and means for applying fluid pressure adjacent the top only of the oil filled area of the sand to expel the oil downwardly therethrough.

14. An oil recovery installation comprising a mine gallery formed adjacent an oil sand but spaced therefrom by material substantially impervious to fluids, an oil collecting pipe in said gallery and connected at a plurality of points with the bottom only of the oil sand, a separator into which said collecting pipe discharges, means for forwarding separated oil and gas to the surface of the earth, a surface well extending into the upper part of the oil sand, means for forcing an oil expelling gas through said well into the sand, and means for determining the pressures prevailing in the gas filled area of the sand and at the points of withdrawal of oil therefrom.

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