Oct. 6, 1931. P. J. SPINDLER 1,826,371

METHOD OF TREATING OIL FIELDS

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Fig. 1.

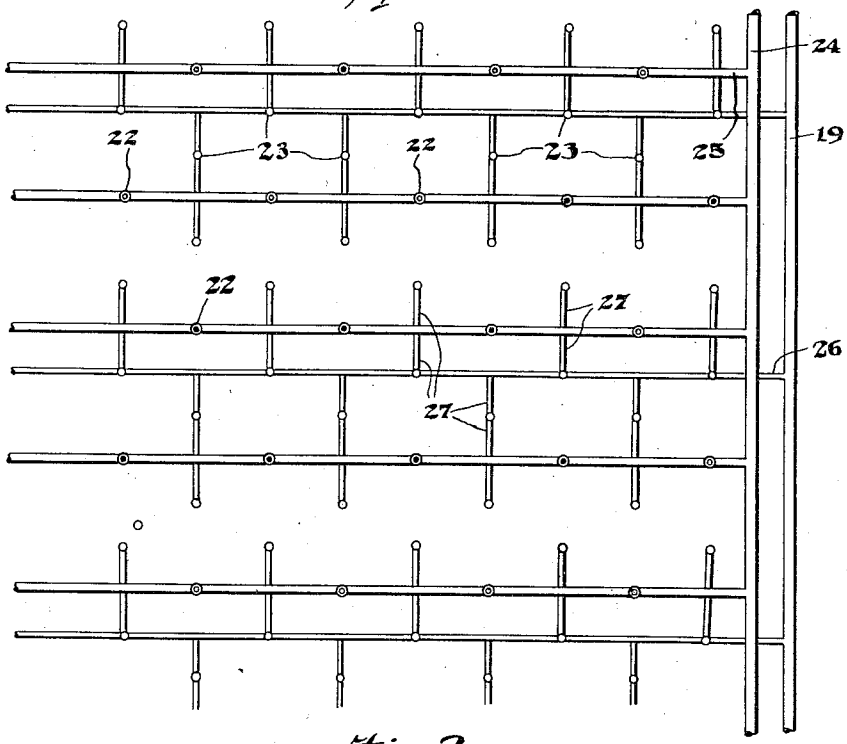
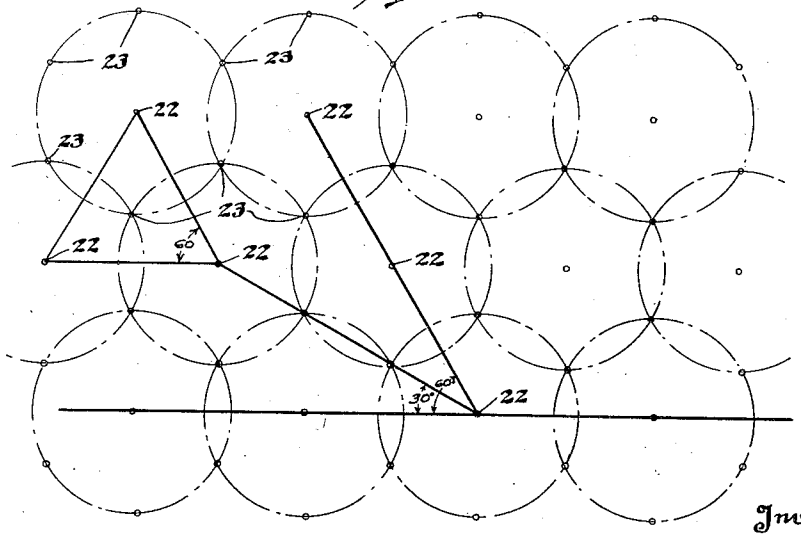


Fig. 2.



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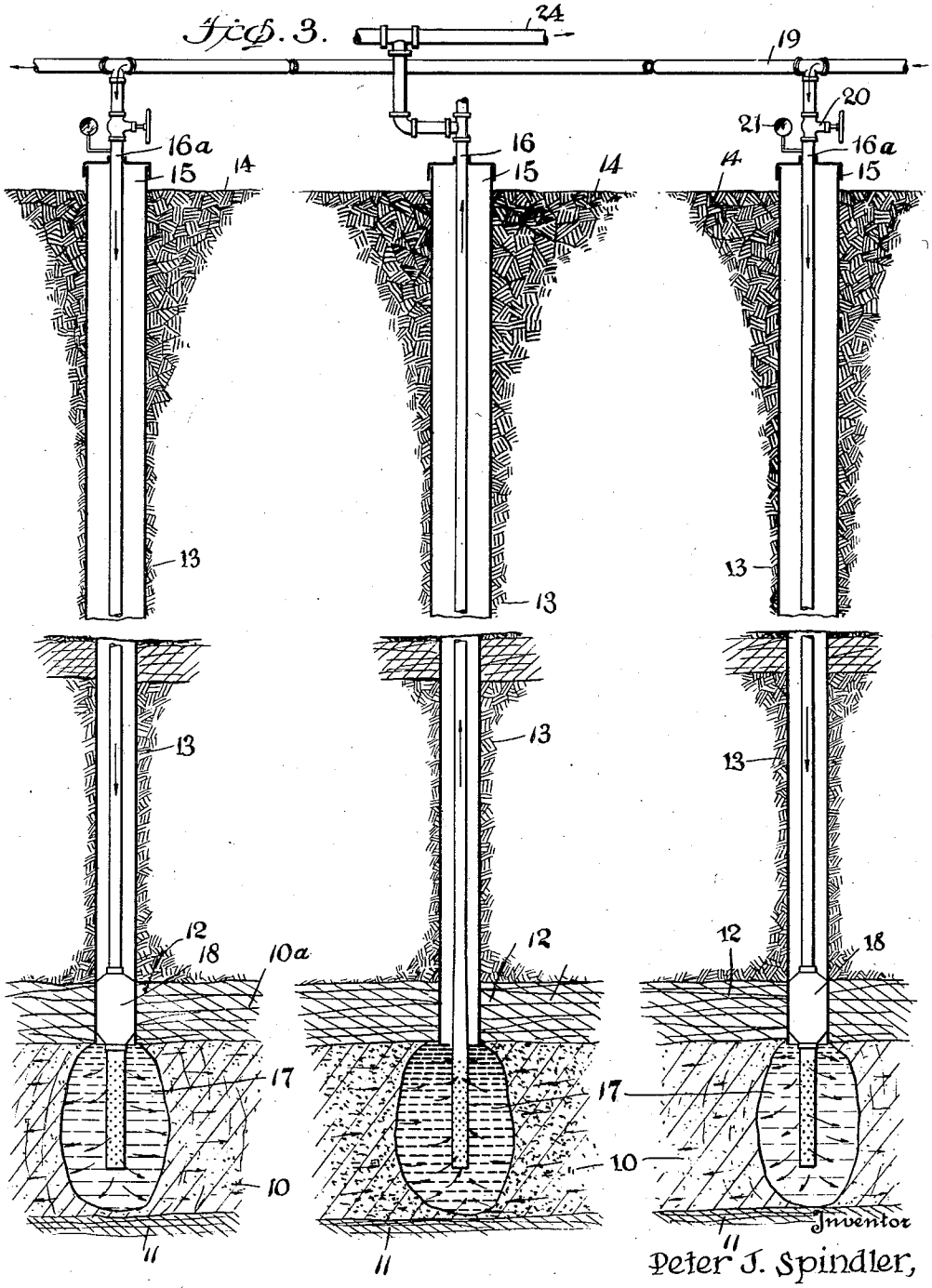
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METHOD OF TREATING OIL FIELDS

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Fig. 3.



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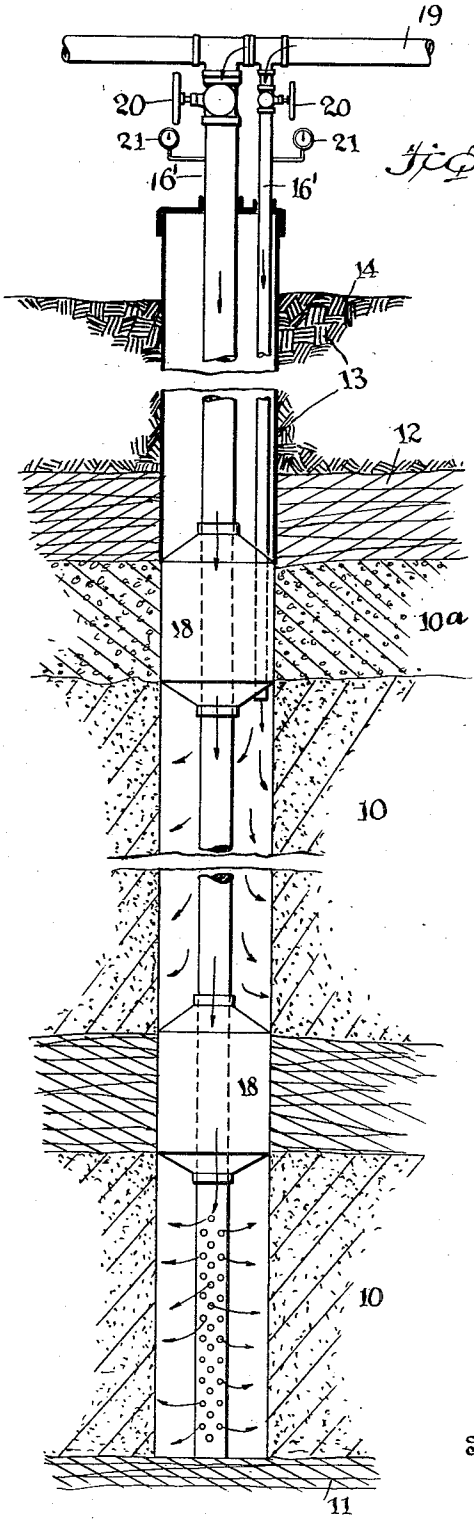


Fig. 4.

Fig. 5.

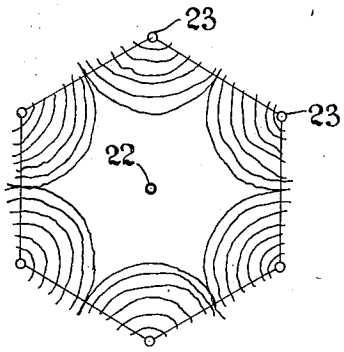
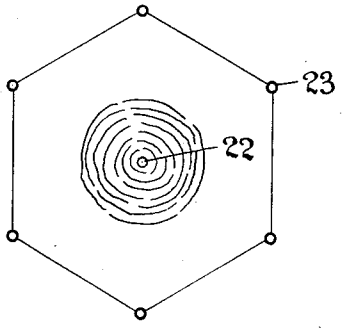


Fig. 6.



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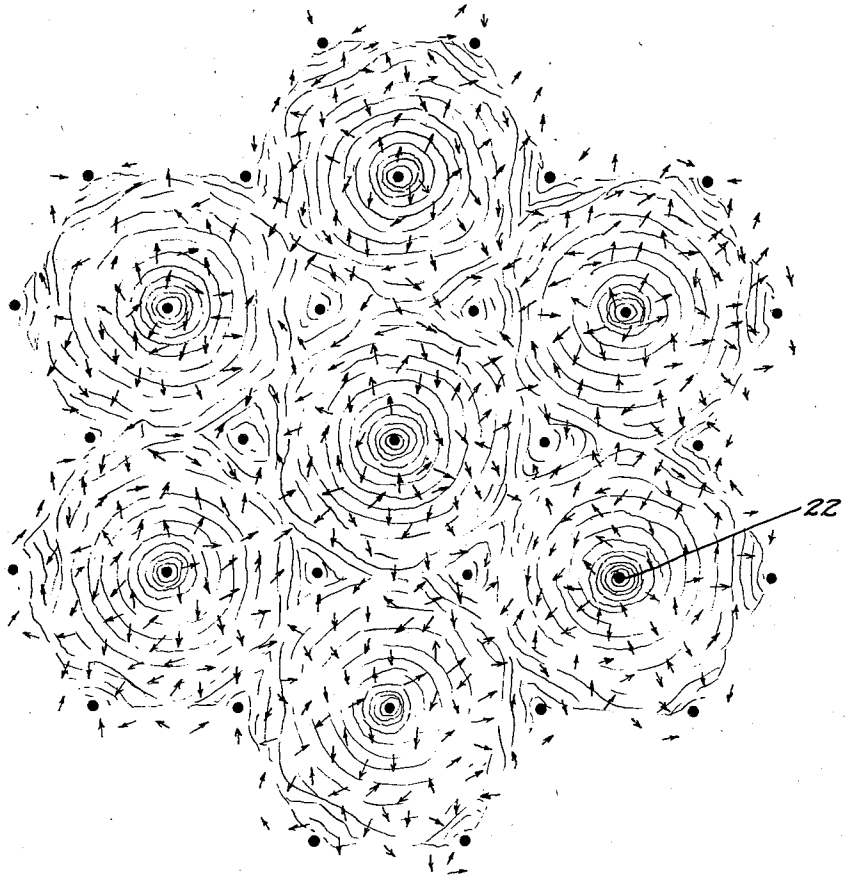
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METHOD OF TREATING OIL FIELDS

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Fig. 7.



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UNITED STATES PATENT OFFICE

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METHOD OF TREATING OIL FIELDS

Application filed April 4, 1930. Serial No. 441,606.

This invention relates to a simplified layout for and method of working oil fields by which larger yields of oil from oil-bearing strata may be obtained. The method involves the application of fluid pressure, either liquid or gaseous, to the oil-bearing sand or strata and when liquid is utilized flooding or pressure wells are provided about the oil well.

In the method of recovering oil from oil sand presently in use the total quantity of oil contained in the sand is not recovered. Said method is not adapted for such recovery since the flow of oil from the sand is dependent on the oil pressure therein. The expulsive flow of the oil results in a rapid outflow and poor recovery, as a considerable percent of the oil remains in the sand. Under some conditions it is estimated that thirty percent is obtained on gushing. The flow of oil from these partially depleted sands proceeds after the initial gushing at a very slow but fairly constant rate.

This flow has been materially aided by introducing into the well certain oil soluble gaseous materials, or highly volatile substances such as natural gas or the volatile fragments of gasoline. The introduction of these oil soluble materials under pressure creates a new flow of oil from the sand by virtue of the increased pressure therein and of the greater mobility of the resulting solution of oil and oil soluble material. These combined features aid in overcoming the resistance offered to the flow of oil through the sand with resultant continued and increased flow.

It has also been suggested that the residual oil within the partially depleted oil sands be removed by means of a driving pressure. Unsatisfactory and unsuccessful application of this has been tried using compressed air as the motivating medium.

In another method of working, the oil sand under exploitation is surrounded by a barrier impervious to the oil. It has been the usual practice to drill through the oil sand along the boundary of the working and flood these boundary wells with an oil impervious material. The so encompassed oil is prevented from escaping from the working to adjacent workings, oil being obtained from the so enclosed and entrapped sand by expelling the same by means of air or gas under pressure.

In the recovery of oil by using a flooding method, great difficulty has been encountered due to unequal distances from well to well with consequent introduction of water into the effluent oil well by channeling within the sand or by an ineffective advancing barrier of water with a consequent incomplete clean-up of the oil.

The position and relation of the flooding wells and their relative distance from each other and from the oil venting well is a matter which has received but scant attention. The haphazard manner in which the wells have been placed with respect to one another has resulted in incomplete clean-up of the residual oil. Under such circumstances the encroachment of the flooding fluid to the venting well does not occur at substantially the same moment from the various points surrounding the well. A penetration of fluid from the flooding well thereafter delivers the flooding fluid; notwithstanding the fact that an incomplete clean-up of oil has occurred. The advance of the water through the sand bears a definite relation to the porosity of the sand and the pressure of the fluid introduced into the flooding well.

When air or gas is utilized the flooding well, or pressure hole, is surrounded by oil wells.

My invention has for its objects to provide a method wherein the distance of the flooding wells from each other and from the venting or oil well, or the distance of the venting wells from each other and from the pressure well, is equal or substantially so throughout

an oil field; to provide what might be termed a homologous system by which uniformity of the spacing is insured; and to provide a simple method by which a repressuring of the oil-bearing strata may be accomplished with a minimum operation and expense.

The invention further has for its object to provide an improved system and layout for the working of oil fields.

In the drawings:

Fig. 1 is a view depicting the improved layout for the oil field.

Fig. 2 is a diagrammatic view illustrating the general working of the system.

Fig. 3 is a vertical section of the oil field showing certain wells therein.

Fig. 4 is a vertical section showing the working of a field containing a plurality of oil sands.

Fig. 5 is a diagrammatic view showing the operations under the liquid drive system.

Fig. 6 is a similar view showing the operations under the air of gaseous repressuring system.

Fig. 7 shows the action of a compressible fluid in the oil sand.

A porous oil-bearing strata or sand 10 containing mineral oil therein under such pressure that the natural flow of such oil to the surface has ceased or which flows with reduced vigor, overlies a strata of rock 11 which is substantially impervious to oil or water. The oil sand is overlain by a gas sand 10*a* containing no oil and is capped by a strata 12 which is non-porous and impenetrable to oil or water, and above this is the overburden 13 of other strata, clay, earth and humus to the surface 14.

Oil wells fitted with suitable casings connecting the sand to the surface, contain pipes 16 and 16*a* therein, certain of which 16 are designed to carry oil from the sand and others 16*a* to lead an oil-expelling fluid which in the first form of the invention, is substantially incompressible, such as water, to the sand. An enlargement of the well is produced in the sand by shattering the same and the reservoir 17 is formed adjacent the lower end of the pipe 16 or 16*a* for retaining the excess of oil or water. A tight packing 18 is provided immediately above the oil sand and the non oil bearing strata or sand to prevent the escape of fluid through any sand except the oil sand.

A main water supply line 19 carries water to the various flooding wells and it is introduced into the said wells under definite pressure. The pressure of the flooding fluid is reduced by means of a reduction valve generally illustrated at 20 and regulated to the desired degree of pressure as noted by means of the pressure indicator 21. The flooding fluid enters the oil strata and, by virtue of the imposed pressure, and of the porosity of the sand, travels therethrough in a plane substantially parallel to the plane of the strata pushing the entrapped oil before it. As indicated in Fig. 3, oil gradually collects within the reservoir immediately under the oil venting well by virtue of the imposed pushing force of the flooding fluid as previously mentioned.

Where the oil bearing sand is overlaid by a depleted gas sand, pebble sand, or clover seed sand, in which there is no oil, this particular sand is packed off as indicated at 18, and the flooding fluid introduced directly thereunder into the oil bearing strata.

In those particular cases in which several oil bearing sands 10 (Fig. 4) are found overlying one another, the working may be carried out by a procedure in which the casing carries a plurality of flooding conduits 16, or of venting conduits as the case may be. The separate oil sands are packed off in the usual manner and to each a conduit is led from the main water supply conduit 19 furnishing flooding fluid whereby the flooding fluid enters the separate strata and is caused to move outwardly therefrom, and push before it the entrapped and subsequently collected oil. As mentioned above, the porosities of the various sands differ materially one from the other and effectively prevent the use of a single source of flooding fluid having the same static head. This variation in porosities necessitates the use of flooding fluids of a definite head for a definite single strata. The requisite head is supplied from the water main 19 through the reducing valves 20 and regulated to the desired pressure by consulting the pressure indicators 21.

The flooding fluid which is designed to expel the oil from the strata is introduced, and by virtue of the reservoir a face or wall of fluid contacts with the oil bearing strata from its lower to its upper surface. In those cases where the porosity and permeability of the sand differ it is greater in the direction of the strata from that in a plane perpendicularly through the strata it is of material importance to impose such a wall of fluid to the sand and move it uniformly through the sand in the plane of the strata.

In laying out the field, a "central" well 22 is surrounded by six other wells 23, making seven in all. This permits of the six wells being equally spaced from each other and with an equal spacing of said six wells forming equi-arcs about the central well, it is a hepta-homologous arrangement. Now with a plurality of the "central" wells arranged in an equi-lateral triangular relationship, and with an imaginary connecting line between two adjacent central wells, intersecting a chord between adjacent wells perpendicularly thereto, the adjacent two flooding wells in the liquid driving system (or the adjacent two venting or oil wells in the repressuring system) are common to each of the two central wells, and one of these adjacent flooding wells (or vent-

ing wells) is common to the three adjacent and triangularly arranged central wells.

By this homologous arrangement the surrounding wells are equally spaced from each other and from the central well. The driving or pressing water from each flooding well is joined with that of the adjacent flooding well before it approaches sufficiently close to the venting well to break through thereinto at the weaker point or points.

By exerting pressure upon the flooding fluid, which may vary up to 1800 lbs. or greater according to the porosity of the sand, the distance of the wells from one another, the depth of the sand and other factors, the flooding fluid is caused to move uniformly through the sand toward the oil venting well. The fluid flooding means forms an oil impervious barrier surrounding the well. As may be seen in Fig. 5, flooding wells 23 placed at equal distances from one another, as an average figure 200 feet, (although there are many factors to be considered in choosing the distance) surround the oil venting well 22 and this well is equi-distant from all the flooding wells. The results of such an arrangement are to effectively create the oil impervious barrier about the well before there is a possibility for the fluid to break through the sand and reach the well. In the case illustrated, where the wells are spaced 200 feet one from the other, the flooding fluid travels 100 feet outwardly from each well to form the barrier, but must travel 200 feet to reach the well. If the wells were spaced in triangular form about the oil venting well and spaced 200 feet apart, the flooding fluid would still have to travel 100 feet before a continuous barrier was formed. The venting well would, however, be only 115 feet from the flooding well. It will be readily seen that any configuration and relation of the flooding wells and oil venting well, except that disclosed in the present method, will not provide the assurance of the formation of a barrier completely surrounding the well before the flooding liquid reaches the well and breaks through into the well. Under such a contingency there is a consequent decrease in the flow of oil, added expense attendant on the operation of pumping quantities of flooding fluid from the well, and additional time requirement to clean up the oil in the given sand.

In a complete lay-out of an oil field which is adapted to be worked by the present method disclosed as invention, a plurality of hepta-homologous arrangements of oil venting wells and flooding wells is provided. Where this arrangement is provided, a plurality of rows of wells runs longitudinally of the oil field. Between the separate rows of oil wells are drilled a row of flooding wells. It will be noted that all lines bearing an angular relation of sixty degrees to that passing through the oil wells will intersect oil wells only. While a line bearing an angular relation of thirty degrees with the above-mentioned lines will intersect two flooding wells between two oil venting wells.

A better recovery of oil is obtained when flooding with an incompressible fluid, such as water, by drilling the flooding wells prior to drilling the venting wells, and thereafter introducing the flooding fluid. The fluid thus introduced into the oil sand seeps through the sand and builds up a liquid flooding barrier which is more efficient in its clean-up than obtained under the prior practice when the oil venting wells were drilled at the same time as the flooding wells. Under the practice of delayed drilling of the oil venting wells, economy of operation is materially aided.

The particular advantages accruing from the arrangement as set forth above whereby a complete barrier of flooding fluid is caused to be formed about a given venting source, provide not only an efficacious method of complete oil clean-up within the field, but also allow an economy and simplicity in the arrangement of piping to the flooding wells and from the venting wells. In Fig. 1, which is illustrative of an ideal arrangement, the water pressure mains 19 are placed transversely of the oil field, and usually at one end thereof. For purposes of economy in inspecting and repairing these particular lines, the oil collecting main 24 is placed in parallel position and adjacent to the water main 19. These mains may be of any desired size depending upon the extent of working and upon the quality of fluid flowing therethrough and from the oil field.

Auxiliary water supply mains 26 lead from the water main 19. The oil main 24 has connected thereto a feeder pipe 25 which in turn, connects the well heads of each oil venting well 16 which it is desired to serve. The auxiliary water supply mains are placed for purposes of economy parallel to the feeder oil main. While the arrangement of piping outlined above is the ideal one, many factors will enter into the final disposition of the pipe lines. Insofar as the topography of the region will permit the above mentioned parallel arrangement is adhered to. A desired economy will be effected by so arranging the oil collecting pipes that any gravity flow to the storage tanks may be used advantageously. Connecting pipes 27, usually one inch, are provided leading from the auxiliary supply whereby fluid communication with the various flooding wells is obtained.

The description, as disclosed, provides for the working of oil fields by the use of an incompressible fluid, such as water. Under some conditions, it is desirable and advantageous to use a fluid which is compressible, such as air, natural gas, carbon dioxide, etc.

Under such conditions, the central wells 22 are used as flooding wells and the fluid introduced therethrough, permitting it to move outwardly from the flooding source. Under this "re-pressuring" system, hereinafter more fully described, oil is vented from those wells surrounding the central flooding wells.

In the method of working, the connecting pipe lines shown in Fig. 1 as oil venting and collecting lines 24 will function as the carrier of the compressible flooding fluid, whereas the flooding lines 26 therein, collect and transport the vented oil to storage.

In this method of working, the same arrangement of drilled wells is used. This configuration requires a central well surrounded by a plurality of spaced wells, said surrounding wells being spaced equidistant one from the other and from the central well. In this method, an efficacious clean-up of the oil is obtained by "repressuring" the oil sand. That is to say, air or other compressible fluids, is introduced into the strata through the central well, the oil contained in the strata being moved throughout the strata on increasing the pressure therein.

As shown in Fig. 6, in this method of working the compressible fluid, air, carbon dioxide, natural gas, ethane or other lower fragments of petroleum are introduced under pressure through the central well 22. The initial pressures are quite substantial varying up to 100 to 500 lbs., or higher.

This is the initial pressure of the compressible fluid being pumped into the sand, and depending upon the variable factors, such as thickness of the strata, area of the field, porosity of the sand, quantity of residual oil in the sand, etc., the pumping is continued for several days or even several months to build up the desired pressure in the sand. The high pressures obtaining at the well head gradually recede as the compressible fluid seeps through the sand, creating a substantially uniform static pressure therein throughout the entire repressured area. As shown in Fig. 7, the compressible fluid may flow in a straight line from the entrant well or take a circuitous path as the porosity of the rock changes or as impenetrable barriers are encountered.

Air, under substantially high pressure, when introduced into the strata oozes rapidly therethrough, and within a comparatively short space of time, a uniformly increased pressure is obtained through the sand. Additional introduction of air under a substantially lower pressure, the pressure being in average cases approximately 150 lbs., causes the oil to flow outwardly from the central well toward the collecting wells surrounding said central well, and the oil is vented from the surrounding wells at a substantially constant rate as the pressure in the same is maintained.

What is claimed is:—

1. The method of working oil fields which comprises simultaneously introducing a flooding fluid into an oil bearing strata at substantially equidistant intervals in the strata, and venting the oil from the strata at a distance from the flooding entry, which distance is substantially the same as that of the flooding intervals.

2. The method of working oil fields which comprises venting the oil from a well in fluid communication with an oil bearing strata, providing a plurality of flooding wells in fluid communication with said strata substantially equidistant from the venting well and from each other, introducing a flooding fluid and causing said fluid to encroach upon the venting well from all sides under influence of static pressure.

3. The method of working oil fields which comprises flooding the oil strata through a plurality of wells substantially equidistant from each other and withdrawing oil from an oil-venting well which is spaced from the flooding wells at a distance substantially equal to the distance between adjacent flooding wells.

4. The method of working oil fields which comprises the exertion of static pressure upon a flooding fluid in fluid communication, at a plurality of substantially equidistant intervals, with an oil bearing strata, whereby the oil is caused to flow in the strata toward a vent, in fluid communication with the strata, said vent being spaced from flooding sources at an interval substantially equal to their distance apart.

5. The method of working oil fields which comprises the steps of forming a fluid barrier by flooding the oil bearing strata with an incompressible fluid medium through wells in fluid communication with the strata and spaced apart at equidistant intervals, exerting static pressure upon said fluid whereby said barrier is moved through the strata, and venting oil from the strata through a well spaced from the flooding wells at a distance equal to their distance apart, as the flooding fluid encroaches upon the venting well.

6. The method of working oil fields which comprises forming a fluid barrier by flooding the oil bearing strata with a fluid medium through wells in fluid communication with the strata and spaced at equidistant intervals, exerting pressure upon said fluid whereby said barrier is moved through the strata, and venting oil from the strata through a well in fluid communication with the strata as the flooding fluid encroaches upon the venting well, said well being spaced from the flooding wells at a distance not less than the distance between adjacent flooding wells.

7. The method of working oil fields, consisting in providing substantially parallel

rows of oil wells, then applying fluid pressure, as by means of water holes, at six points about each well equally spaced from each other and from the specified well enclosed thereby, with each pressure point being equally spaced from said specified well and two adjacent companion wells.

8. The method of working oil fields, consisting in drilling three wells to the oil bearing strata, with the spacing between the three wells being substantially equal whereby the wells will be disposed at the apices of a substantially equilateral triangle, then applying fluid pressure to the strata through two of the wells and venting fluid from the strata through the third well.

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