Feb. 5, 1952 E. S. MERRIAM ET AL 2,584,605

THERMAL DRIVE METHOD FOR RECOVERY OF OIL

Filed April 14, 1948

Fig. 1.

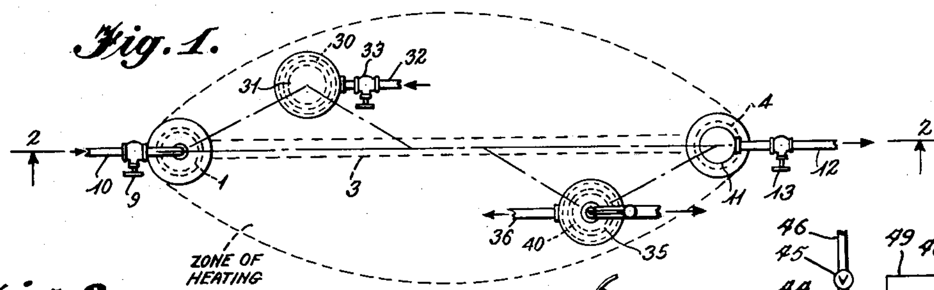
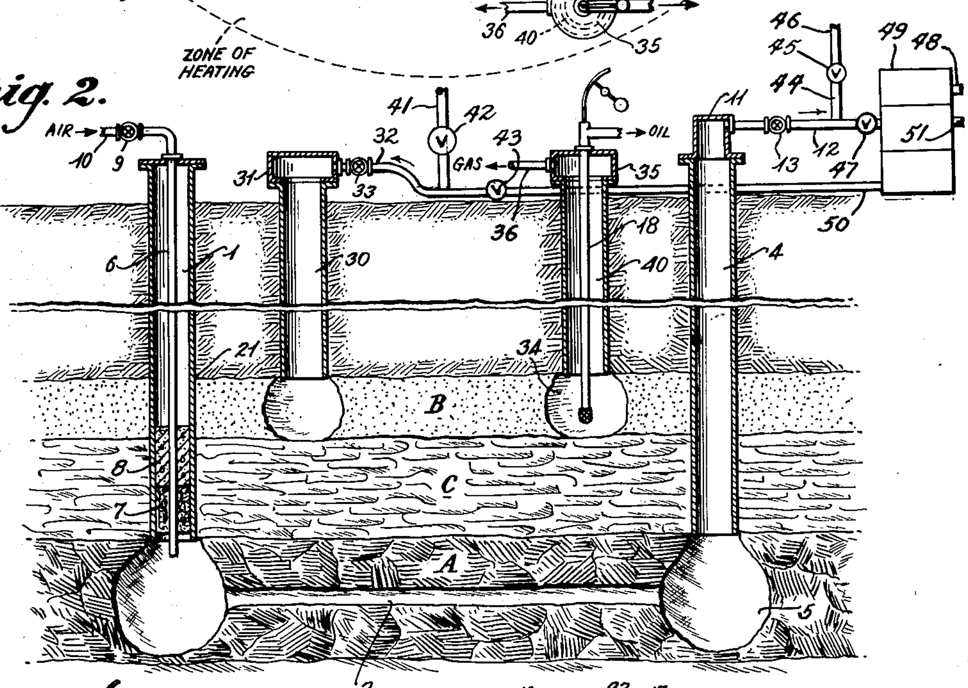



Fig. 2.



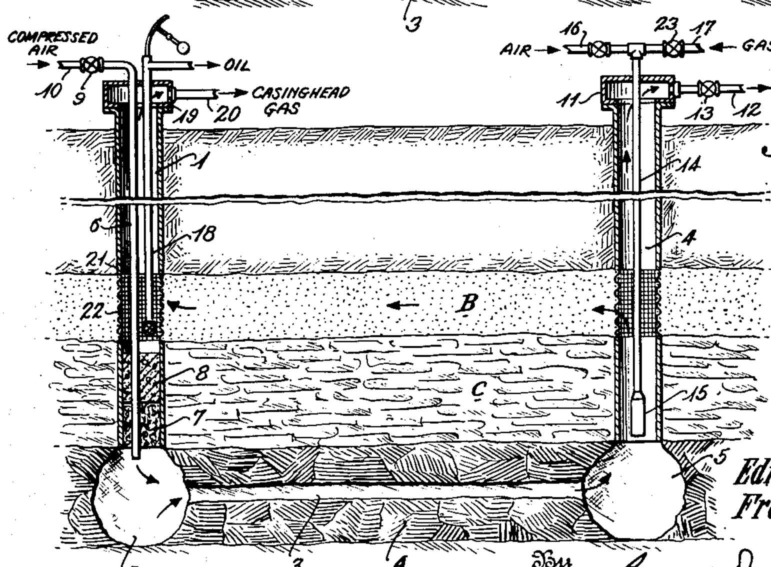




Fig. 3.

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Patented Feb. 5, 1952 2,584,605

# UNITED STATES PATENT OFFICE

2,584,605

## THERMAL DRIVE METHOD FOR RECOVERY OF OIL

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Application April 14, 1948, Serial No. 21,004

16 Claims. (Cl. 166—21)

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This invention relates to the recovery of petroleum. More particularly, the invention relates to a method for the recovery of oil from oil sands which are located in geological formations interstratified with coal seams, ligneous deposits or other combustible organic matter.

Petroleum is usually found associated with sandstone or porous limestone deposits situated between impervious layers of shale, or rock and the like. In most instances, the oil contains lighter gaseous hydrocarbons, such as methane, ethane, propane, etc., which may exist as free gases in contact with the oil or dissolved in the oil itself. The pressure under which the oil and associated gases exist is equal to the hydrostatic pressure of a column of water equal to the depth of the deposit below the surface. When such an oil bearing sand is reached by drilling, oil is produced by flowing to the surface under the expansive force of the gases at well pressures, whether the gases are free or dissolved in the liquid oil. Thus, the oil and gas are both forced into the region of low pressure around the well bottom. Depending upon the total pressure exerted, and the conditions at the mouth of the well, the upward movement of the oil and gas may create a flush production, for example, in the form of a gusher. During this stage of production, most of the gas associated with the oil escapes, and the motive power bringing the oil to the surface is dissipated.

Pumping is then initiated in order to continue to recover oil. During this stage, gas associated with the oil continues to escape from the casinghead. Subsequently, the flow of oil becomes economically unprofitable with respect to further utilization of pumping means.

When the well attains this condition in which the heavier hydrocarbons obstruct the pores of the sand and no longer flow freely to the well bottom, the method of repressuring the well system is commonly practiced. This involves forcing back into selected central wells air or gas which penetrates the sands and finds exit from the adjacent wells communicating with the oil reservoir under treatment. The air or gas mechanically forces the crude oil to the venting well bottoms where it is removed by pumping, and the more volatile portions of the residual oil are entrained in the gas or air stream and thus removed from the well.

In time repressuring becomes no longer expedient, and final resort may be had to the flooding of the oil field with water to drive additional amounts of the residual oil contained in these

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sands into the wells. After flooding has been utilized to the point where it is no longer profitable, the flooded field becomes non-productive and must be abandoned.

It is well known that in the fields subjected to the foregoing treatment, nearly half of the oil known to be initially present is still left as residual oil in the sands. At the present time, the problem of recovering this vast amount of residual oil has become an urgent one, particularly due to the increasing demand for petroleum and petroleum products, and the rapidly diminishing number of discoveries of new oil fields.

It has heretofore been recognized that oil may be recovered by applying heat to oil-containing sands in their native position. By thus heating the oil-containing sands, the heavier hydrocarbons clogging the pores of the sand are rendered less viscous, and the flow thereof through the sand is facilitated. In addition, the more volatile hydrocarbons are distilled from the sand to the venting well casing. Various methods have been proposed for effecting a heating of the oil sands. For example, direct combustion of a portion of the residual oil utilizing air under pressure, or air and a combustible gas to initiate and support combustion of the oil has been proposed. It has also been proposed to pass heated products of combustion in gaseous form through the oil sands in order to effect a heating thereof, whereby the viscosity of the residual oil is reduced and the oil becomes more mobile. However, these prior methods have certain inherent disadvantages which are obviated by the present invention.

Where direct combustion of a portion of the residual oil is practiced, it is extremely difficult to control the extent of combustion, and regardless of control, the method inherently involves destruction of an appreciable portion of the oil itself. On the other hand, the method employing heated products of combustion, necessitates a continuous supply of combustible gases, which supply must be immediately available at the location in order to render the method feasible. In addition, use of gas requires that the gaseous products of combustion be introduced into the oil sands under high pressure and, therefore, involves the continuous use of compressors or the like.

In many oil fields, particularly those of Pennsylvanian or Mississippian geological age, coal seams, ligneous deposits, or veins of similar combustible organic matter are often found closely associated with the oil-containing sands. Such coal seams, ligneous deposits, or other combustible organic matter represent an available source of potential heat energy far in excess of the amount which would be required to supply a thermal drive by which oil in the adjacent oil-containing sands may be heated and thereby recovered. The present invention is directed to a method in which the heat energy existing in such coal seams, ligneous deposits and other combustible organic matter is utilized in situ, thus supplying the heat necessary for recovery of the oil in the oil-containing sands. In addition, the invention contemplates the use of such deposits of combustible organic matter as the source of fuel necessary to provide the mechanical energy for operation of the process.

It is, therefore, a primary object and purpose of the present invention to provide a method for the recovery of oil from oil reservoirs located in geological formations interstratified with other combustible organic matter.

It is a further object of the invention to provide a method for recovery of oil in which a thermal drive for effecting release of the oil from the oil-containing sands is created by combustion of combustible organic matter adjacent to the oil sands.

It is another object of the invention to provide a method for the recovery of oil from oil-containing sands and the like in which no source of heat produced above ground is employed.

Another object of the invention is to utilize the products of combustion of the combustible organic matter as a source of fuel for supplying the mechanical energy necessary for operation of the process.

It is a still further object of the invention to provide a method for the recovery of oil from oil-containing sands and the like in which destruction of the residual oil by combustion is substantially avoided, while sufficient heat is supplied to effect efficient recovery of oil.

A further object of the invention is to provide a method for the recovery of oil in which the recovery is facilitated by means of heat emanating from a subterranean source adjacent to or contained in the oil-containing sands or the like.

Another object of the invention is to provide a method for establishing a channel through a subterranean seam of combustible organic matter.

Essentially, the method of the present invention comprises subjecting coal, ligneous or other combustible organic matter interbanded with the oil-containing sands to combustion, thereby furnishing the heat which effects a distillation of the more volatile portions of the oil and fluidizes the remaining portions of the oil by rendering it less viscous, and then withdrawing the vaporized and fluidized oil.

With combustion occurring along the entire length of the vein of combustible organic matter, a large portion of the adjacent oil sands are effectively heated by conduction through the intervening layers of shale or rock and the like. This increase in temperature of the oil-containing sands renders more fluid the semi-solid hydrocarbons clogging the pores of the sand, that is, their viscosities are greatly reduced. Any normally solid hydrocarbons which may have previously been precipitated are redissolved in the liquefied hydrocarbons. In all cases the heavier hydrocarbon liquids become less viscous and more mobile. In addition, the vapor pressure of both the connate water and the hydrocarbons of the oil are greatly increased. This causes an increase in the pressure existing in the oil-containing sands. The thus volatilized and fluidized residual oil moves in the direction of a zone of lower pressure which exists at the communicating well bottoms and is there withdrawn by suitable means such as pumping.

In order to provide for initiating and maintaining combustion of the seam of coal, lignite or other combustible organic matter, the method of the present invention contemplates establishing communication with a located seam interstratified with respect to the oil-containing sands. This may be accomplished simply by drilling as in the case of oil wells, or by sinking a shaft of relatively larger diameter as is customarily done for water wells, or by operating from existing coal mines.

In order to actively burn a subterranean seam of coal or the like, a combustion supporting gas must continuously pass through such seam. Under these conditions, after ignition of the coal or other combustible organic matter at one end of the seam, combustion continuously progresses along the length of the seam. In general, maintenance of combustion is insured only by establishing a direct path or channel for the combustion supporting gases through the length of the seam. One of the principal features of the present invention is the provision of means for establishing horizontal channels along the length of such seams of combustible organic matter. In addition, the invention contemplates locating the end of such path or channel with respect to the surface, and establishing communication therewith from the surface to provide a continuous passage for the combustion supporting gases and gaseous products of combustion. The combustion supporting gases may then be continuously passed down through the input shaft or well into the channel established in the seam, and the gaseous products of combustion are vented through the exit or chimney well communicating with the end of the horizontal channel. Thus, after ignition of the seam at the input end thereof, combustion is continuously maintained.

The flame started at one end of the seam is carried into the bed and the original path or channel becomes enlarged by burning of the combustible matter so as to permit an increased volume of combustion supporting gas to pass through the channel with consequent combustion of increasing amounts of the coal or the like.

In some instances, a coal or lignite seam is found to be sufficiently permeable to the combustion supporting gases injected under suitable pressure to allow ignition at one end thereof and continued combustion without the necessity of establishing a channel through the seam.

Heat from combustion of the coal or the like passes to the adjacent oil-containing sands by conduction through any intervening shale deposits or the like. The oil being highly heated develops an increased pressure, and the more volatile portion is distilled out of the sands, while the heavier hydrocarbon portions are rendered sufficiently fluid to be recovered by draining or forcing toward zone of lower pressure.

Various procedures may be utilized to recover the oil according to the thermal drive method of the invention. Two or more wells may be drilled at selected positions within the heated zone. These wells communicate only with the oil sands.

By introducing a gas under pressure into one of such oil wells, the heated vaporized and fluidized oil is forced into the other well or wells communicating with the oil sands and is removed therefrom by any suitable means, such as pumping. Of course, existing oil wells adjacent to the seam of burning combustible organic matter may be utilized as the repressuring and producing wells. Also the gaseous products of combustion issuing from the chimney or exit well communicating with the seam of burning coal or the like may be used, as the repressuring gas.

Alternatively, if the input shaft and/or the chimney well communicating with the seam of coal or the like also communicate with the oil sands, they may be employed as the oil producing wells.

In the foregoing embodiments of the invention, the wells employed as the oil producing wells may be selected so that the flow of oil is either concurrent or countercurrent with respect to the flow of heat within the heat zone created by combustion of the seam of coal or the like.

According to the above procedures, only that portion of the heat from the combustion which is transmitted both vertically and horizontally by conduction through intervening strata is utilized to effect a heating of the oil. In other words, the sensible heat contained in the gaseous products of combustion is not utilized to heat the oil sands, and passes with these products out through the exit or chimney well. Since the coal, lignite or other combustible organic matter burned in this manner is in excess of the oxygen contained in the combustion supporting gas, such as air, the gaseous products of combustion issuing from the chimney well will contain appreciable amounts of carbon monoxide and other combustible gases, together with smoke and tar vapors. They comprise essentially a good type of producer gas. Such products of combustion may be utilized as fuel for boilers or the like in order to operate prime movers which drive the necessary blowers, compressors, etc. These gases may also be utilized as fuel for the refinery and gasoline plants, if the same are located in the area.

It is a preferred embodiment of the invention, however, to effect a substantially complete utilization of the sensible heat contained in the gaseous products of combustion. This may be accomplished in the case where communication exists between the chimney well and the oil-containing sands by closing the chimney well after ignition of the coal seam. The gaseous products of combustion are thus forced from the chimney well through the adjacent oil-containing sands by the pressure of the continuous stream of combustion supporting gas introduced into the input shaft and the channel in the coal seam. In this manner, substantially all of the available heat created by combustion of the seam is realized as heat input to the residual oil in the oil-containing sands. The oil is recovered either from the input shaft which also communicates with the oil sands or from a separate producing well in the zone of heating.

The volume of the gaseous products of combustion exceeds the volume of combustion supporting gas necessary to maintain active combustion of the coal. With the chimney well closed a high pressure is developed in situ in the channel located in the coal seam and in the chimney well bore and bottom. By increasing the pressure of the combustion supporting gas supplied to the seam to a value in excess of the pressure developed by the products of combustion, the heated gaseous products of combustion are forced into and through the oil-containing sands imparting additional heat thereto. Thus, the sands containing the oil are not only heated by direct conduction through the intervening strata and by the sensible heat contained in the products of combustion, but also a positive drive due to the pressure developed is set up within oil sands. This mechanical drive facilitates movement of the vaporized and fluidized residual oil toward the zone of lower pressure, at the producing well bottom. The total volume of combustion gases may exceed the amount desired for introduction into the oil sands. In such instance the excess gas may be passed to repressuring wells in the system which do not communicate with the burning seam. In the case where the oil sands do not communicate with the chimney well or input shaft for the coal seam, the hot gaseous products of combustion issuing from the chimney well are forced under pressure into the repressuring well and thus into the oil sands. The sensible heat therein is thus imparted to the oil.

In some instances where the combustion of the coal, ligneous material or other organic combustible matter is quite incomplete, the products of combustion in gaseous form will contain condensable vapors of tarry or resinous material. In such case, the condensable tars and the like may precipitate after coming into contact with cooler regions of the oil-containing sands and rapid clogging of the porous sands may ensue. Should such a problem exist, still another alternative embodiment of the present invention may be adopted.

According to this alternative procedure, the chimney well for the burning coal seam is left open to act as an exit for the gaseous products of combustion containing the condensable tarry materials which may be utilized as fuel, as mentioned above. Communication is established with the oil-containing sands only within the zone of heat created by combustion of the seam of coal or the like. In some instances, this may be accomplished by utilizing existing wells communicating only with the oil sands. In this embodiment there can be no communication between the end of the coal seam entering the chimney well and the oil-containing sands. If such communication exists, it is eliminated by the use of packers or by cementing. Air or other gas under pressure is then supplied to the oil-containing sands through this repressuring well to provide a positive drive for the heated residual oil through the sands to the producing well or wells.

In order to advantageously utilize the sensible heat contained in the gaseous products of combustion, while employing this alternative procedure the following refinement of this procedure may be adopted: The pipeline for supplying air or gas to the oil-containing sands is positioned in heat exchange relation to the hot gaseous products of combustion issuing from the chimney well. Thus, heat exchange will occur between the repressuring air or gas and the highly heated gaseous products of combustion, whereby the sensible heat in the products of combustion will be extracted by the air and the heat thus absorbed by the air will be carried into the oil-containing sands.

A second alternative method to prevent clogging of the oil sands by the condensable tars and resins contained in the gaseous products of combustion may be adopted. In this alternative embodiment of the invention, communication exists between the oil sands and the chimney well. The chimney well is closed after active combustion of the coal or the like has been initiated. Air under pressure is then introduced through the capped chimney well by a pipe extending to the bottom of the well in order to completely burn the organic material, such as the condensable tarry vapors resulting from the incomplete combustion of the coal or the like. If necessary, a gas burner is introduced into the bottom of the chimney well to aid in completing the combustion of the products resulting from the burning of the coal. Thus, the hot clean gases produced by complete combustion at the bottom of the chimney well, together with the gases produced by the burner operation, penetrate the oil-containing sands by the pressure developed in situ, and impart the sensible heat contained therein to the sands driving the oil out by distillation and by mechanical movement to the zone of lower pressure at the producing well bottom.

As stated above, some of the naturally occurring coal or lignite seams are sufficiently permeable to gases to allow ignition thereof and maintenance of combustion by penetration of combustion supporting gases. However, in most instances a direct channel or path must be established in the seam to be subjected to combustion.

The present invention contemplates the use of several means for establishing a path for the combustion supporting gases through the seam of combustible organic matter.

Known methods of horizontal drilling may be employed. These involve operating from a mine, from a shaft, or from a well. For instance, one method is to sink a well to the seam of coal or the like and greatly enlarge the hole at the coal level by shooting. An unbrella type of whipstock can then be lowered to the shot hole and spread into position. A flexible cable carrying a rotating bit is then operated from the whipstock in order to effect horizontal drilling. In this manner, a direct path or channel of the desired length may be produced in the seam of coal or the like to be burned.

The final position of the bit at the end of the horizontal bore with respect to the surface is then determined. This may be done in several ways. For example, the compass method may be employed in which a compass of the marine type having a needle imbedded in paraffine or the like attached to a flexible cable is pushed to various positions along the bore. The paraffine is electrically melted and then allowed to resolidify, thus fixing the position of the magnet at the given point. A plot of the location of the horizontal bore may then be made, and knowing the position of the original well, a second well may be drilled to communicate with the end of the horizontal bore. A second method consists of plotting electrical resistance between an electrode at the end of the bore hole with another electrode moved to various positions on the surface. In this manner, the point on the surface vertically above the end of the horizontal bore may be determined. A well is then drilled to establish communication with the end of the horizontal bore.

The lower end of the drilled well will not in all probability initially directly communicate with the end of the horizontal bore. However, it will be located immediately adjacent to the bore, and communication may be established by exploding charges inserted into the well bottom and into the end of the horizontal bore.



A communication is thereby established between the first and second well, or between a mine or shaft and the second well. The second well serves as a chimney or exit well for the gaseous products of combustion at least when the seam is first ignited. Combustion is then maintained by continuously supplying the combustion supporting gas to the seam through the first or input well and the coal actively burning constantly enlarges the horizontal bore through the seam. Irregularities in direction and partial obstruction in the channel within the seam are of little consequence as they will burn away.

Another method by which a direct path or channel may be produced in the seam of the coal or the like is effected by hydraulic lifting within the seam. In this method an incompressible fluid, such as oil or water, is forced down an existing or drilled well which is in communication with the seam. The fluid is placed under a pressure greatly in excess of the pressure existing in the seam. For example, a pressure of one pound per square inch for each foot of depth must be exceeded. In an adjacent existing or drilled well communicating with the seam to be channeled, the fluid is also introduced under the same pressure. The fluid under this pressure acts as a hydraulic jack and causes the seam to separate along the lines of weakness. An actual channel is thus formed between the two wells. After a channel is established, the pressure on the fluid at one well is released. A movement of fluid through the channel from the well under pressure to the other well occurs, thereby scouring out the path established.

A still further means of establishing communication through the combustible seam between the wells may be adopted. For example, a machine gun may be mounted on the umbrella type of whipstock and explosive bullets fired into the seam progressively penetrating further into the seam. The channel thus established may be flushed and cleaned between successive shots.

Other means by which a direct path through the seam may be produced include so-called directional shooting, and the use of an oxygen lance connected to the end of a flexible hose. All the above methods may be used singly or in combination.

The present invention is more fully described and illustrated by reference to the accompanying drawings, the figures of which illustrate the various alternative embodiments of the present invention and are not intended to constitute a limitation thereof in which:

Figure 1 is a diagrammatic representation in plan of an oil field interstratified with coal to which the method of the present invention is applicable;

Fig. 2 is a diagrammatic view, partly in section taken on line 2—2 of Fig. 1, of that embodiment of the invention in which there is no communication between the oil sands and the coal seam; and

Fig. 3 is a diagrammatic representation, partly in section, of that embodiment of the invention in which the oil sands communicate with the coal seam.

Referring to Fig. 1, a well 1 communicates with a seam of coal, through which a horizontal bore 3 is established. A chimney well 4 is drilled into the coal seam from the surface near the closed end of bore 3, thereby establishing a continuous passage for a combustion supporting gas in order to burn the coal seam. Oil wells 30 and 40 are drilled into the oil-containing sands adjacent to the coal seam. Upon combustion of the coal, a zone of heating is created which volatilizes and fluidizes the oil in the sands within the zone of heating. The oil is recovered by introducing air or a gas under pressure into the heated oil sands through well 30 or 40 and pumping the other well.

Referring now to Fig. 3, a coal seam A is shown located below an oil containing sand B, with an intervening layer of rock or shale C. This represents conditions which often occur in certain geological formations where oil is found, particularly in strata of Pennsylvanian and Mississippian age. A well 1 is drilled to establish communication from the surface with the located coal seam A.

At the bottom of well 1 a shot-hole 2 is formed by means of explosive charges, thereby enlarging the diameter of the well bottom. An umbrella type of whipstock is lowered into the shothole and spread into position. A flexible cable carrying a rotating bit is operated from the whipstock to effect horizontal drilling through the coal seam. After a horizontal bore 3 of the desired length has been drilled, the end of the bore is located with respect to the surface according to the methods described. Communication with the end of the bore is then established by drilling well 4. Explosive charges are then set off at the bottom of well 4 and at the end of the bore 3 effecting a communication between the two shot-holes 2 and 5 and the wells 1 and 4.

After removal of the drilling apparatus, well 1 is capped, and pipe line 6 is inserted into the well. This line carries a packer 7 which is placed just above the coal seam. A cement plug 8 is then placed above the packer nearly up to the oil sand. Pipe line 6 establishes a direct communication between coal seam A and a source of compressed air fed through valve 9 and line 10. The chimney well 4 is also provided with a casinghead 11 and with an exit line 12 for the gaseous products of combustion of the coal. Line 12 is provided with a valve 13 for controlling the flow of the gaseous products of combustion. The cap of well 4 carries a pipe 14 extending nearly to the bottom of well 4. A burner 15 may be attached at the lower end of pipe 14. Pipe 14 may carry air alone supplied from line 16 or a combustible mixture of air and gas supplied from lines 16 and 17. Well 1 is provided with a pump 18 extending to the level of the oil sand. The casinghead 19 of well 1 is provided with an outlet 20 through which gases issuing from the well can be taken to a stripping plant, and then to a boiler by means of which the necessary power to operate blowers and compressors can be generated. The gaseous products of combustion by passage through the oil sands are enriched in combustible vapors, so that the stripped gases constitute an excellent fuel.

The coal seam may be initially ignited in any suitable manner, as by electrical means, or by a squib, or incendiary shell dropped down pipe line 6. To ensure ignition a cylinder of oxygen may be discharged into pipe line 6. Air under pressure is then continuously supplied to the coal seam through line 6. Valve 13 providing an exit for the products of combustion from chimney well 4 is initially left open until ignition of the coal near shot-hole 2 and along the bore is actively under way. After a suitable period, valve 13 is closed and the pressure of the air entering pipe 6 is raised. The products of combustion of the coal are therefore forced to traverse the oil sand B back toward well 1. Heat from the burning coal seam A enters the oil sand increasing the vapor pressure, and lowering the viscosity of the oil. The hot gaseous products of combustion enter the sand and tend to move the thinner fluids toward the region of lower pressure above the cement plug 8 in well 1. The products of combustion leave the casinghead at 20 much enriched by the volatile portions of the oil. The displaced liquefied oil is removed from shothole 2 by pump 18.

The gaseous products of combustion containing the volatile distilled oil fractions are sent to a suitable stripping unit not shown in the drawings. The stripped gases may be utilized as repressuring gas for adjacent oil sands not communicating with the burning coal seam and, therefore, not traversed by the combustion gases.

Although not shown in Fig. 3, the oil may be driven to an existing or drilled well communicating with the oil sands, which functions as a producing well in place of well 1, such as well 30 or 40 as shown in Fig. 1. In such a modification the casing 21 of well 1 seals off communication of well 1 with the oil sands, replacing the cylindrical screen 22.

The above-described procedure may be somewhat modified where due to the incomplete combustion of the coal, appreciable amounts of condensable tarry vapors are formed, and pass into the oil-containing sands with the gaseous products of combustion, thereby tending to clog the pores of the sands. With reference to Fig. 3, in this modification compressed air is fed through line 16 to pipe line 14 inserted through the casinghead 11 of chimney well 4. The air thus injected into chimney well 4 mixes with the heated gaseous products of combustion in the slot-hole 5 and effects further oxidation of the incompletely oxidized constituents thereof. As a result, clean hot gases containing a minimum of condensable tarry vapors are forced under pressure into the oil-containing sands.

A further modification consists of attaching a suitable gas burner 15 to pipe line 14 in the chimney well 4 prior to capping this well. A gas line 17 is provided with valve 23 connected to pipe line 14 inserted through the casing of the chimney well 4, and constitutes means for supplying gas to the burner. Upon operation of the gas burner, complete oxidation of any condensable tarry vapors is effected prior to passage of the gaseous products of combustion into the oil-containing sands B.

Referring now to Fig. 2, a preferred embodiment of the invention is shown wherein the gaseous products of combustion do not traverse the oil sands. In this embodiment no communication exists between the input well 1, bore 3 or chimney well 4 for the coal seam, and the oil sands B. Drilled wells 30 and 40 communicating only with the oil sands are utilized for the recovery of the oil.

Air or gas under pressure is introduced into the casinghead 31 of well 30 through line 41, valve 42, line 32 and valve 33, valve 43 being closed. The heated oil in sands B is driven into the well bottom 34 of well 40, and is recovered by pump 18. The air or gas containing the volatile oil fractions is vented from casinghead 35 of well

40 through line 36 which leads to a stripping plant.

The gaseous products of combustion are vented from chimney well 4 through valve 13, lines 12 and 44, valve 45 and line 46, valve 47 being closed. This producer gas may be used as fuel for boilers or for driving prime movers to supply the mechanical energy for operating compressors, and the like.

These hot gases after removal of tar vapors may alternatively be recirculated through the oil sands by introduction under pressure into well 30 thereby imparting their sensible heat to the oil sands.

An alternative procedure consists of using air or some other gas as the repressuring agent and heating the same by passage through line 48, heat exchanger 49, line 50, valve 43 and the input line 32 (Fig. 2) for well 30. Gaseous products of combustion vented from chimney well 4 pass through valve 13, line 12, valve 47, heat exchanger 49 and exit through line 51. It will be observed that in the process described, the pressuring gas passes in heat exchange relationship with the gaseous products of combustion vented from the chimney well. Valves 42 and 45 are closed when this alternative procedure is practiced.

The method of the present invention advantageously utilizes substantially all of the available heat energy contained in the combustible organic matter to provide a thermal drive for effecting the recovery of oil from oil-containing sands. In addition, no source of heat extraneous to the geological formation under treatment is required.

The method of the present invention effects a recovery of substantially all of the oil contained in the sands except for undistillable residues, and substantially avoids any destruction of the oil by direct combustion thereof.

The invention also provides the novel means of establishing communication through the seam of coal, or the like by hydraulic lifting.

Having thus described our invention, we claim:

1. A method for the recovery of oil from oil-containing deposits located in geological formations interstratified with other combustible organic matter, which comprises supplying a combustion supporting gas to the organic matter, initiating and maintaining combustion of said organic matter thereby heating by conduction the adjacent oil, passing the hot gaseous products of combustion under pressure through the oil-containing deposits to further heat the oil thereby vaporizing and fluidizing the same, moving the oil toward a zone of lower pressure under pressure exerted by the gaseous products of combustion, and withdrawing the thus vaporized and fluidized oil from said zone of lower pressure.

2. A method according to claim 1 in which the heated gaseous products of combustion containing condensable oxidizable constituents are contacted with additional combustion supporting gas prior to passage through the oil-containing deposit.

3. A method according to claim 1 in which the heated gaseous products of combustion containing condensable oxidized constituents are subjected to further combustion prior to passage through the oil-containing deposit.

4. A method for the recovery of oil from oil-containing deposits located in geological formations interstratified with other combustible organic matter which comprises supplying a combustion supporting gas to the organic matter, initiating and maintaining combustion of said organic matter thereby heating by conduction the adjacent oil to vaporize and fluidize the same, passing a gas under pressure through the oil-containing deposit to force the oil toward a zone of lower pressure, and withdrawing the thus vaporized and fluidized oil from the region of lower pressure.



5. A method for the secondary recovery of oil from oil-containing deposits located in geological formations interstratified with other combustible organic matter which comprises supplying a combustion supporting gas to the organic matter, initiating and maintaining combustion of said organic matter thereby heating by conduction the adjacent oil, venting the hot gaseous products of combustion to the surface, passing a gas under pressure in heat exchange relation to the hot vented gaseous products of combustion into the oil-containing deposit to further heat the oil thereby vaporizing and fluidizing the same, forcing the oil through the oil-containing deposit by pressure of the gas toward a zone of lower pressure, and withdrawing the thus vaporized and fluidized oil from the zone of lower pressure.

6. A method for producing oil from partially depleted oil-containing sands located in geological formations interstratified with seams of other combustible organic matter which comprises drilling an input and a chimney well into the seam at selected positions along the length thereof, said chimney well being in communication with the oil-containing sands, establishing a channel through said seam between said wells, passing a combustion supporting gas under pressure through said input well and channel, initiating and maintaining combustion of the organic matter in the seam thereby heating the adjacent oil-containing sands by conduction, closing said chimney well after initiation of combustion, forcing the heated gaseous products of combustion from the chimney well through the oil-containing sands thereby further heating the oil to volatilize and fluidize the same, moving the thus volatilized and fluidized oil to a producing well by pressure of the gaseous products of combustion, and recovering the oil from the producing well.

7. A method for producing oil from partially depleted oil-containing sands located in geological formations interstratified with seams of other combustible organic matter which comprises drilling an input and a chimney well into the seam at selected positions along the length thereof, establishing a channel through said seam between said wells, passing a combustion supporting gas through said input well and channel, initiating and maintaining combustion of the organic matter in the seam thereby heating the adjacent oil-containing sands by conduction, venting the gaseous products of combustion through said chimney well to the surface, passing a gas under pressure into the oil-containing sands through another well communicating therewith to force the thus heated oil into a producing well, and withdrawing the oil from the producing well.

8. A method according to claim 7 in which the gas passed into the oil-containing sands is maintained in heat exchange relation to the hot gaseous products of combustion vented from the chimney well.

9. A method according to claim 7 in which the gas passed into the oil-containing sands com-

prises the vented gaseous products of combustion.

10. A method for producing oil from partially depleted oil-containing sands located in geological formations interstratified with seams of other combustible organic matter which comprises drilling an input and a chimney well into the seam at selected positions along the length thereof, said chimney well being in communication with the oil sands, establishing a channel through said seam between said wells, passing a combustion supporting gas through said input well and channel, initiating and maintaining combustion of the organic matter in the seam thereby heating the adjacent oil-containing sands by conduction, closing said chimney well after initiation of combustion, contacting the heated gaseous products of combustion containing condensable oxidizable constituents with additional combustion supporting gas in the chimney well thereby removing the condensables by oxidizing the same, forcing the thus treated gaseous products of combustion from the chimney well through the oil-containing sands thereby further heating the oil to volatilize and fluidize the same, moving the thus vaporized and fluidized oil from the sands to the input well by pressure of the gaseous products of combustion, and withdrawing the oil from the input well.

11. A method according to claim 10 in which a gas burner is operated at the chimney well bottom in the presence of a combustion supporting gas to remove the condensables by oxidizing the same prior to passage of the products of combustion through the oil-containing sands.

12. A method for the production of an enriched combustible gas from oil-containing deposits located in geological formations interstratified with other combustible organic matter. which comprises supplying a combustion supporting gas to the organic matter, initiating and maintaining combustion of said organic matter thereby heating by conduction the adjacent oil, passing the hot gaseous products of combustion under pressure through the oil-containing deposits to further heat the oil thereby vaporizing and fluidizing the same, moving the oil toward a zone of lower pressure under pressure exerted by the gaseous products of combustion, and separately withdrawing the gaseous products of combustion enriched in combustible vapors by passage through the oil-containing deposit.

13. A method for the recovery of oil from geological formations in which oil and other combustible organic material are present in different strata which comprises igniting said other organic material to provide heat requisite to reduce the viscosity of said oil and withdrawing the said oil from the said formation.

14. The method of claim 13, in which said other organic material is coal.

15. The method of claim 13 in which said other organic material is lignite.

16. A method of producing oil from geological formations in which oil and other combustible organic material are present in different strata which comprises interconnecting an input well and a chimney well which penetrate the stratum containing said other combustible organic material by means of a channel passing through said stratum, said chimney well also being in communication with an oil bearing stratum, initiating combustion of said other organic material in said channel to provide heat to and reduce the viscosity of said oil, passing a combustion supporting gas under pressure through said input well and into said channel to maintain said combustion, and withdrawing said oil from the geological formation, at least a portion of the products of said combustion being vented through said chimney well.

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