A method of extracting immobile hydrocarbons includes the steps of sinking spaced wells into the hydrocarbon formation, fracturing the formation near the bottom of the wells to establish subsurface communication between the wells, passing a heated fluid through the wells and the hydrocarbon formation to obtain a predetermined temperature in the formation and finally passing a solvent material, having the ability to dissolve the immobile hydrocarbon, through the hydrocarbon formation so that the admixture of the solvent and hydrocarbon can be brought to the surface and allowed to solidify into a fuel composition which can be transported at normal atmospheric conditions in solid form and can be easily melted into liquid fuel.

13 Claims, 2 Drawing Figures
1 METHOD OF EXTRACTING IMMOBILE HYDROCARBONS

The present invention generally concerns a method of extracting immobile hydrocarbons from the earth and more particularly concerns a method of extracting immobile hydrocarbons from the earth by converting the hydrocarbons in situ into a flowable state and in a manner such that the resultant product of the extraction is a solid fuel composition.

Public utilities supplying gas for fuel find it necessary to curtail or interrupt deliveries to industrial and commercial customers when system demands exceed the supply available. These customers are then required to switch to an alternate fuel, such as fuel oil, until adequate supplies of gas are again available. Facilities for alternate fuel are costly and require considerable space and furthermore, these facilities are generally inadequate to supply peak load fuel requirements for sustained periods such as occurs during periods of unseasonably cold weather and periods of mechanical difficulty in gas distribution systems and the like. Storage for alternate fuels frequently requires bulky steel tanks which in some cases are pressurized, and during periods of fuel shortages, replenishment of the alternate fuel for the tanks becomes difficult and at times impossible due to temporary unavailability of tank cars, tank trucks and other vehicles suited for transporting liquid fuel.

It is accordingly an object of the present invention to provide an alternate fuel having a high BTU content that does not require tank cars, tank trucks or other liquid fuels transporting means to transport the fuel to storage and use locations.

It is another object of the present invention to provide an alternate fuel material which does not need to be stored in bulky steel tanks or pressure storage tanks.

It is another object of the present invention to provide a new and improved method of extracting immobile hydrocarbons from the earth. It is another object of the present invention to provide a new and improved method of extracting immobile hydrocarbons from the earth by in situ conversion of the immobile hydrocarbon into a liquid state and flowing the hydrocarbon to a surface location where it is naturally solidified at atmospheric temperatures.

It is another object of the present invention to provide a method of extracting immobile hydrocarbons from the earth by passing a solvent material through the in situ formation of hydrocarbon to dissolve the hydrocarbon and thereby entrain the hydrocarbon in a fluid flow to the surface where it is allowed to solidify under atmospheric conditions.

Viscous hydrocarbons, such as heavy oils, bitumen, tar sands, asphalts, and asphaltities and the like, are difficult to produce from native formations using conventional oil field production practices. Numerous schemes have been tried using pressure, heat, solvents, etc., to induce mobility and while some of these schemes have been technical successes, they have been economic failures. The present invention involves a new and improved method of extracting viscous or immobile hydrocarbons by converting the hydrocarbon in situ into a flowable condition so that it can be removed from the earth in a liquid state. In accordance with the present invention, an injection well and a removal well are sunk into the hydrocarbon formation and the hydrocarbon formation is fractured or otherwise connected between the lower ends of the wells in a conventional manner to establish communication with the bottoms of the wells. The immobile hydrocarbon material in the formation can be converted into a flowable state by passing a preheated liquid material at a temperature in excess of the melting point of the hydrocarbon formation through the injection well, the fractured formation and the removal well to melt the hydrocarbon and thereby remove it in a liquid state. Preferably, however, the hydrocarbon material is converted to a flowable state by dissolving the hydrocarbon with a suitable solvent material which will carry the dissolved hydrocarbon to the surface in a liquid state. Since some suitable solvents have melting points above normal atmospheric temperatures, it is necessary to preheat these solvent materials and also the hydrocarbon formation so that the solvent material itself will remain in a flowable condition while dissolving the hydrocarbon.

The resultant composition of the hydrocarbon material and the solvent material has a melting point above normal atmospheric temperatures so that the composition solidifies upon being exposed to atmospheric conditions. The solid composition is combustible and thereby forms a new fuel material which overcomes the many disadvantages of liquid fuel in that it can be readily transported and stored and does not require the unique equipment necessary to transport and store liquid fuels. Of course, the solid fuel can be easily converted into liquid form merely by heating and thereby becomes ideally suited for use as most conventional liquid fuels.

Other objects, advantages and capabilities of the present invention will become more apparent as the description proceeds taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a diagrammatic vertical section taken through a hydrocarbon formation to illustrate the initial phases of the method of the present invention.

FIG. 2 is a diagrammatic vertical section similar to FIG. 1 with portions removed and illustrating a later phase of the method of the present invention.

By way of illustration and not limitation, the present invention will be described in connection with the extraction of gilsonite from the earth, it being understood that the described method and resultant solid fuel product would be equally applicable to other immobile hydrocarbons such as asphalt, grahamite, glance pitch, tar, bitumens and others.

Gilsonite is a unique crude petroleum that remains a solid at normal atmospheric conditions. As found in nature, it is usually pure and is located in a massive, near vertical fracture system varying in width from a few inches to over 20 feet, and in depth from surface outcrop to more than 1500 feet. Gilsonite is relatively soft with a specific gravity of 1.03 to 1.10 at 77°F and with a pour point of 230°F to as high as approximately 500°F depending upon the specific gravity. It's heat content is in the range of 18,000 to 18,800 BTU's per pound. Gilsonite is not flammable below it's melting temperature.
and is nontoxic and furthermore, gilsonite is relatively inert to most chemicals, non-corrosive, and has a low sulfur content.

In extracting gilsonite from the earth in accordance with the present invention, an injection well 10 and a removal well 12 are sunk into a gilsonite formation 14 by conventional oil field drilling techniques. By way of example, the well bores could be 9 inches in diameter, spaced approximately fifty feet apart and sunk into the earth to the approximate depth of the gilsonite formation. Of course, the spacing between the wells would vary with the width of the gilsonite vein and the difficulties encountered in establishing sub-surface circulation between the bottoms of the wells. The circulation between the bottoms of the wells is established by conventional oil field practices, which would include explosive or hydraulic fracturing, pressure solvent opening, or directional drilling of the gilsonite formation or the surrounding rock formations. This establishes communication in the form of passage 16 between the bottoms of the wells through which liquid will flow.

After the wells have been drilled, a surface casing 18 is set in each well bore, for example 6% inch casing, to an approximate depth of 50 feet with the casing 18 being set and the lower end thereof cemented in place. Next, inner tubing and outer liner tubing 20 and 22 respectively, for example 2 inches and 4% inches in diameter respectively, are suspended in each hole by a conventional oil field "christmas tree" assembly (not shown) at the top of each well. Initially, both tubing and liner are extended to the total depth of each well and left open at the bottom so as to be in communication with the fracture or passages 16 in the gilsonite formation 14. To insulate the inner tubing and liner from the surrounding gilsonite forming and thereby minimize heat loss during circulation procedures to be described later, the liner is preferably provided with an inner coating of foamed silicate insulating material or the like and the annular space between the liner and the gilsonite formation is filled with a gelled oil or the like.

The christmas tree assemblies at the top of the wells are interconnected by a common flow line 24. The connection of the flow line 24 to each assembly is through a T-joint having one arm 28 in communication with the inner tubing 20 of the associated well and the other arm 30 in communication with the outer liner 22 of the associated well. Conventional adjustable valve devices 32a and 32b for the injection well and 34a and 34b for the removal well are incorporated into the arms of the T-joint to selectively control the flow of material associated with the inner tubing and outer liner respectively, through either the inner tubing, the outer liner or both.

A liquid pump 36 and a conventional liquid heating unit 38 are incorporated into the flow line 24 so that liquid material can be continuously pumped through the flow line and heated during the process. Also, the flow line 24 is provided with an inlet line 40 and an outlet line 42 so that liquid materials can be injected into the flow line 24 or removed therefrom when desired. Of course, conventional adjustable valve devices 44 and 46 connect the inlet and outlet lines, respectively, to the flow line 24 so that the flow of material can be regulated. Additionally, a control valve 48 is incorporated into the flow line 24 between the inlet and outlet lines to selectively block the flow line, for example when material is being withdrawn from the flow line through the outlet line 42.

It will be appreciated that after the wells have been provided with the aforementioned tubing and connected in communication both sub-surface and above surface as described, a closed circulating path is established through the injection well 10, the fractured or opened up gilsonite formation, the removal well 12 and the flow line 24.

After the aforementioned closed circulation path is established, a hot heating liquid such as water or brine is circulated through the closed circulation path to elevate the temperature of the gilsonite. If the hot water or brine has a temperature in excess of the melting point of the gilsonite, the gilsonite can be melted in place and will flow with the water or brine to the surface through the removal well 12 so that it can be extracted through the outlet line 42 from the system.

Preferably, however, the hot water or brine is circulated through the fractured gilsonite formation at a temperature of approximately 250°F and at a rate of approximately 300 gallons per minute until the gilsonite formation, at least along the passages 16, obtains a temperature of, for example, 200°F. Preferably, the heating liquid would be injected into the formation through the inner tubing 20 of the injection well 10 via valve 32a and similarly removed from the formation through the inner tubing 20 of the removal well 12 via the valve 34a for a reason to be explained later.

After the gilsonite formation obtains a temperature of approximately 200°F, the heating liquid circulation is terminated. At this time a pre-heated liquid solvent material, such as the heavy or residual fractions of waxy crude oils hereinafter referred to as paraffin, is circulated through the closed circulation path. Of course, other solvent materials suitable for dissolving immobile hydrocarbons similar to gilsonite could also be used. Examples of these solvents would include crude oil, kerosene, fuel oil, amyl nitrate, amyl acetate, benzol, tolulol, terpentine, chloroform, carbon disulfide, carbon tetrachloride, naphtha, and others. The paraffin solvent would preferably have a specific gravity in the range of 0.85 to 1.1, a melting point in the range of 65°F to 160°F and be pre-heated to a temperature of approximately 250°F before it was pumped into the closed circulation path via the inlet line 40 and would be directed into the inner tubing 20 via valve 32a of the injection well and removed through the inner tubing 20 via valve 34a of the removal well. In the even the temperature in the circulating path drops below the melting point of the paraffin, causing the paraffin to freeze in the tubing, a heating liquid could be injected into the outer tubing of each well through the inlet line 40, the heating unit 38 and then split by a valve 35b to pass through the common line to valve 32b connected to the outer tubing of the injection well and a bypass line 35 via valve 35a and 34b to the outer tubing of the removal well to again melt the paraffin and establish production fluid flow. The resultant pressure increase in such a case is reduced by conventional pressure relief valves in the christmas tree assemblies. It is preferable that the paraffin solvent be circulated at a rate of approximately 150 gallons per minute to maintain the hot temperature of the paraffin through the complete circuit. It should be noted that gilsonite is known to readily dissolve in hot paraffin, even though the paraffin temperature may be well below the melting point of
the gilsonite, however, during the circulating process it is possible that chunks of gilsonite may break away from the formation and not have a chance to totally dissolve before it reaches the bottom of the removal well 12. To prevent such chunks from possibly clogging the removal well, a conventional screen or perforated joint 50 can be positioned at the bottom of each well to prevent large chunks of gilsonite from entering the flow lines of the wells, regardless of circulation direction, until dissolved.

The paraffin and dissolved gilsonite is circulated through the closed circuit or circulation path until the gilsonite content of the circulating mixture reaches a desired level of for example 80% paraffin and 20% gilsonite by weight. Of course, other percentage compositions with the gilsonite being as low as approximately 10% of the total weight may be desirable depending upon the desired pour point of the resultant solid fuel which will be described later. Should more than one pass through the circuit be required, the heating unit 38 serves to maintain the composition mixture above the necessary temperature for maintainance of fluid flow.

When the circulating mixture attains the desired percentage content of dissolved gilsonite, the mixture is removed from the circuit through the outlet line 42. Fresh quantities of hot paraffin are added to the circuit as necessary and the process can continue without interruption as production proceeds.

The production procedure continues from the bottom of the mined area toward the top. Accordingly, periodically the tubing in the injection and removal wells 10 and 12 must be raised by stages, FIG. 2, to a point near the bottom face or undersurface 52 of the gilsonite formation remaining in place. In order to assure that the circulating paraffin remains in contact with the undersurface 52 of the gilsonite, the void created by the removed gilsonite must be filled with a backfill material 34 through inlet 53 via valve 53a having a specific gravity greater than the paraffin solvent so that the solvent will float across the top of the backfill material and thereby remain in dissolving contact with the gilsonite. This hot backfill material 54 could be water, brine, mud or the like and is pre-heated to maintain the desired temperature at the undersurface of the remaining gilsonite.

The production process continues by stages until the gilsonite is removed up to the economic limit. Upon completion of the production, the tubing and surface casing may be pulled while the system is hot using conventional equipment commonly found in oil fields. The salvaged equipment can thereby be reused in other wells along the gilsonite formation or at other locations.

The produced mixture of paraffin and gilsonite constitutes a fuel material having a BTU content of approximately 18,500 to 19,600 BTU's per pound and when exposed to atmospheric conditions, remains in a solid state. The mixture may be cut or otherwise divided into convenient sized units, for example, units containing 100,000 BTU's and in convenient shapes, for example, slabs, heavy wall tubes, etc. The produced fuel may also be prilled, or it may be stored in bulk by freezing into vats similar to those used in frasch sulfur mining. If desired, the fuel can be also be melted and the resultant liquid fuel transported in heated tank trucks or tank cars as is conventional with other liquid fuels.

The fuel produced as described above, can be produced to specifications, for example a melting point of 175°F, at the time it is removed from the circuit. The melting point of the finished fuel can be set between the melting point of paraffin, for example 120°F and the maximum melting point of gilsonite, for example approximately 500°F. Paraffin readily softens at temperatures encountered in the warm months and thus is troublesome to store without safeguarding the maximum temperature. Gilsonite, on the other hand, will not soften at warm month temperatures, but it is brittle and readily breaks up into explosive dust upon handling. The fuel processed in accordance with the present invention eliminates the undesirable characteristics of both components and may be readily handled, transported and stored with minimum hazards.

The solid fuel composition resulting from the process of the present invention in preferred physical sizes and shapes, can be readily transported by a variety of conveyances normally used for transportation of inert solids and the finished product may be stored with a minimum of precautions, for example in sand and gravel pits near industrial and commercial facilities and plants. Further, the finished product can be used as fuel oil by using sufficient heat to convert the product to a flowable liquid. Thus, the finished product may be readily transported without the necessity of tank trucks and tank cars and used as other conventional liquid fuels during prolonged periods of unseasonably cold weather.

Although the present invention has been described with a certain degree of particularity, it is understood that the present disclosure has been made by way of example and that changes in details of structure may be made without departing from the spirit thereof.

What is claimed is:

1. A method of extracting gilsonite from a gilsonite formation in the earth comprising the steps of:
   establishing injection and removal passages between a surface location and the gilsonite formation,
   establishing sub-surface communication in the gilsonite formation between the injection and removal passages,
   passing a liquid having a temperature above the melting temperature of gilsonite and below 500°F through the formation to melt contacted portions of the gilsonite formation by injecting the liquid material into the formation through the injection passage and removing the material along with the melted gilsonite through the removal passage.

2. A method of extracting gilsonite from a gilsonite formation in the earth with a solvent material comprising the steps of:
   establishing an injection passage and a removal passage between a surface location and the gilsonite formation,
   establishing sub-surface communication in the gilsonite between the passages,
   passing a heating fluid through the formation by injecting the heating fluid into the formation through the injection passage and removing the heating fluid through the removal passage until the temperature of the formation is above the melting point of the solvent material, and
   passing the solvent material, which has the capability of dissolving gilsonite through the formation to dissolve contacted portions of the gilsonite formation.
by injecting the solvent into the formation through the injection passage and removing solvent along with the dissolved gilsonite through the removal passage.

3. The method of claim 2 further including the step of establishing an above-surface flow line for fluid communication between said injection passage and said removal passage, and circulating the heating fluid through the injection and removal passages, the gilsonite formation and the flow line until the temperature of the formation, at least along the path of communication in the formation between the passages, is above the melting point of the solvent material.

4. The method of claim 3 further including the steps of providing a heating unit in the flow line and continuously heating the heating fluid as it is circulated through the injection and removal passages, the gilsonite formation and the flow line.

5. The method of claim 3 wherein said solvent material is circulated through the injection and removal passages, the gilsonite formation and the flow line after the temperature of the formation has been brought to a temperature above the melting point of the solvent material.

6. The method of claim 5 further including the step of substantially filling the void in the gilsonite formation where the hydrocarbon has been removed with a backfill material having a specific gravity greater than the specific gravity of the solvent material so that the circulating solvent material will float on the backfill material in engagement with the undersurface of the remaining gilsonite.

7. The method of claim 2 wherein said solvent material is paraffin.

8. The method of claim 7 wherein said heating fluid is circulated through the gilsonite formation until the temperature of the gilsonite, at least along the path of communication between the wells, is approximately 200°F.

9. The method of claim 8, further including the step of preheating said paraffin to a temperature of approximately 250°F before it is passed through the gilsonite formation.

10. The method of claim 2 wherein said injection and removal passages are spaced injection and removal wells and wherein said injection well has inner and outer longitudinally extending concentric tubes therein and wherein the heating fluid is injected into the inner one of said tubes and the solvent materials is later injected into the inner of said tubes after circulation of the heating fluid has been terminated.

11. The method of claim 10 further including the steps of placing a screening device near the bottom of the removal well and preventing undissolved hydrocarbon particles greater than a predetermined size from passing to the surface through the removal well.

12. The method of extracting immobile gilsonite from the earth comprising the steps of: sinking an injection well and a removal well into the gilsonite formation at spaced location, placing inner and outer concentric tubing in each of said injection and removal wells, connecting the inner tubing of each well and the outer tubing of each well with an above-surface flow line having valve means at opposite ends thereof for selectively establishing communication between the flow line and one or both of said inner and outer tubings, placing a heating unit in communication with the above-surface flow line, providing a closable inlet line and a closable outlet line in communication with said flow line, opening the gilsonite formation between the bottoms of the wells to establish a path for fluid communication between the wells, injecting hot water at a temperature of approximately 250°F into said inlet line at a rate of approximately 300 gals/min., and then circulating the hot water through the inner tubing of each well, the fractured gilsonite formation and the flow line connecting the inner tubing until the temperature of the gilsonite formation along the fracture is at least 200°F, terminating the circulation of the hot water, injecting liquid paraffin at a temperature of approximately 250°F into said inlet line, circulating the paraffin through the inner tubing of each well, the fractured gilsonite formation and the flow line connecting the inner tubing to dissolve the gilsonite, and continuing the circulation until the paraffin obtains a dissolved gilsonite content of approximately 20% by weight, removing the paraffin-gilsonite composition through the outlet line, and allowing the paraffin-gilsonite composition to cool and thereby solidify into a solid fuel material.

13. A method of extracting gilsonite from a gilsonite formation in the earth with a solvent material comprising the steps of: establishing an injection passage and a removal passage between a surface location and the gilsonite formation, establishing subsurface communication in the gilsonite formation between the passages, and passing a solvent material at a temperature below 230°F, which has the capability of dissolving gilsonite through the formation to dissolve contacted portions of the gilsonite formation by injecting the solvent into the formation through the injection passage and removing the solvent along with the dissolved gilsonite through the removal passage.
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,881,551 Dated May 6, 1975

Inventor(s) Ruel C. Terry and Xerxes T. Stoddard

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 32 "fuele" should read --fuel--.
Column 2, line 10, "with" should read --between--.
Column 4, line 49, "even" should read --event--.
Column 5, line 39, "34" should read --54--.

Column 7, line 31 "is" should read --in--.
Column 7, line 35 "siad" should read --said--.
Column 7, line 49 "materials" should read --material--.
Column 8, line 4, "location" should read --locations--.

Signed and Sealed this
Seventh Day of September 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

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