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IGNITING AN UNDERGROUND FORMATION

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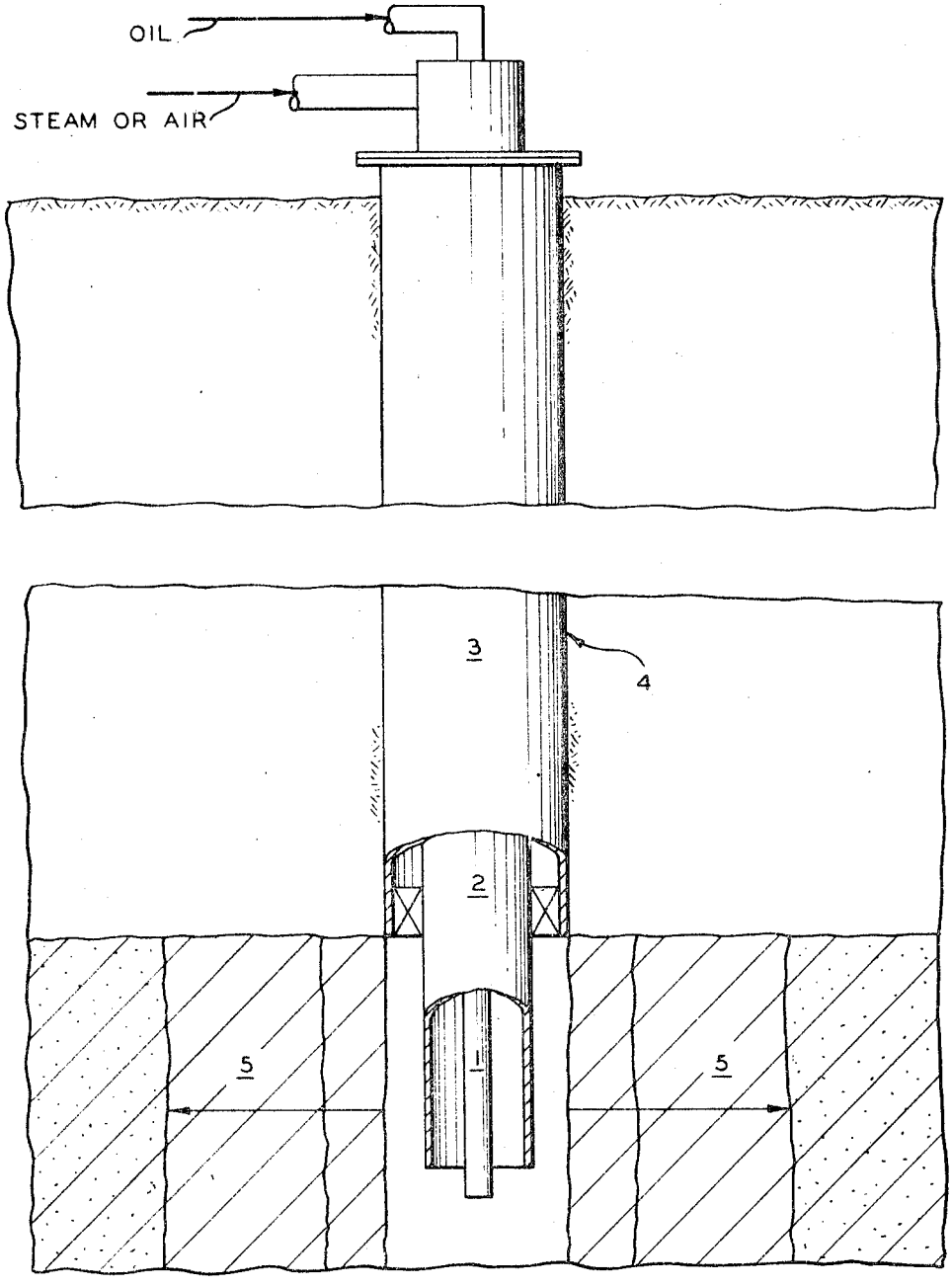

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IGNITING AN UNDERGROUND FORMATION

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ABSTRACT OF THE DISCLOSURE

An underground oil formation is ignited by injecting a heated fluid into said formation to raise the temperature and pressure thereof above the ignition temperature of an auto-ignitable fuel which is injected into the formation after the termination of the flow of the heated fluid, and then injecting an oxygen-containing gas into said formation whereby said auto-ignitable fuel begins burning immediately in the presence of said gas.

This invention relates to a method for igniting an underground formation.

In another aspect, the invention relates to a method of igniting an underground oil formation by injecting sufficient heated fluid into the formation to raise the temperature and pressure so that, upon subsequently injecting a spontaneously ignitable fuel followed by an oxygen-containing gas, the fuel begins burning immediately.

In another aspect, the invention relates to a method of igniting an undergrground oil formation by injecting sufficient steam into the formation to raise the temperature and pressure sufficiently high, so that, upon subsequently injecting an auto ignitable oil into the formation, the oil begins burning, and the combustion zone is propagated throughout the reservoir by injecting an oxygen-containing gas such as air into the formation.

In still another aspect, the invention relates to a method of igniting an underground oil formation comprising injecting sufficient steam into the formation to raise the temperature and pressure sufficiently high, so that, upon subsequently saturating the reservoir to about a 5-foot radius from the well bore with sufficient fuel to ignite the formation, the fuel begins burning immediately when contacted by oxygen.

Heretofore, electrical or fired heaters were suspended in the well bore of an oil containing formation to promote ignition thereof. However, such devices must be maintained in a carefully controlled condition. It is an object of this invention to provide a novel, easily controlled substitute for the use of electrical or fired heaters in the ignition of oil containing formations. Another object is to promote ignition of an underground oil containing formation when the crude oil in the reservoir does not furnish sufficient coke to raise the combustion temperature to a desirable level. Another object is to provide a method of igniting an oil containing, underground formation when injection of a supplementary fuel after preheating of the reservoir appears desirable.

Other aspects, objects and the several advantages of this invention will be apparent to one skilled in the art from a reading of the specification, appended claims and drawing.

Accordingly, the invention provides a method of igniting an underground oil formation comprising injecting sufficient heated fluid into the formation to raise the temperature and pressure of the formation sufficiently high, so that, upon subsequently injecting a sufficient amount of an auto-ignitable fuel, the fuel begins burning immediately in the presence of sufficient oxygen to support combustion. In a preferred embodiment, the heated fluid used

is steam, and injection of the auto-ignitable fuel is followed by injection of an oxygen-containing gas in an amount sufficient to propagate the combustion zone throughout the formation.

Among the fuels which can be used are crude oil, tung oil, linseed oil, tall oil, and mixtures thereof. Gases such as oxygen per se and air can be used to initiate and propagate the combustion zone, and heated fluids such as steam can be used to raise the temperature and pressure of the formation.

The preferred embodiment of the invention can be described with reference to the drawing.

Referring thereto, sufficient heated fluid such as steam is injected through the well bore **4** into the formation **5** via one string of tubing **2**, and, subsequently, a sufficient amount of auto-ignitable fuel to ignite the formation is injected through the well bore via a separate string of tubing **1**. Thereafter, sufficient oxygen is injected into formation **5** via tubing **2** to propagate the combustion zone throughout the formation. A separate string of tubing for the injection of the oxygen-containing gas is required to prevent well bore fires caused by contacting the auto-ignitable fuel with oxygen before reaching the formation.

It is apparent that the pressure under which the heated fluid is injected can vary widely; the higher the pressure exerted upon the formation, the lower the temperature required to ignite the fuel. Typically, sufficient oil is injected to saturate the reservoir to about a 5-foot radius from the well bore. The fuel used in the process of this invention should provide sufficient coke to sustain combustion at the desired temperature level.

The following table shows the initial temperature in degrees Fahrenheit and the ignition temperature in degrees Fahrenheit of various fuels which can be used for in situ combustion in accordance with the practice of this invention. In general, at 1400 p.s.i. air pressure, a self-sustaining exothermic reaction takes place at temperatures between 200 and 300° F.; whereas, at 1 atmosphere of air pressure, ignition occurs at approximately 440° F. Generally, air used to maintain air pressure on the formation will be cooled to 200° F. or below before injection.

TABLE

Fuel	Initial temp., °F.	Air pressure, p.s.i.g.	Ingition temp., °F.
San Roque medium diesel	140	1400	>300
Group II crude	140	1400	285
Group I crude	132	1400	275
Belridge crude	85	150	320

San Roque medium diesel is a diesel oil obtained from the San Roque Refinery in Venezuela. Group II crude is oil produced from the lower zone in the Morichal Field in Venezuela, and is very heavy crude oil. Group I crude is oil produced in the upper zone in the Morichal Field, and is a lighter crude than Group II crude. Belridge crude is crude oil obtained from California, and provides a reference test on an oil known to be auto-ignitable under field conditions.

Following injection and ignition of the fuel, sufficient oxygen containing gas such as air is injected to propagate the combustion zone throughout the reservoir. The amount of air necessary to propagate a combustion zone can be calculated from laboratory determined parameters for a particular formation or an estimate of air requirements can be made from published correlations. Such correlations can be found in an article by Alexander et al., entitled "Factors Affecting Fuel Availability and Composition During In Situ Combustion," Trans. AIME, 1962, 225 1154. If the heated fluid used is steam, as would

be used in a steam flooding process, part of the injected oil and preheat value of the steam can be salvaged during backflow of the well.

The following example indicates the application of the process of this invention.

Example

Differential thermal analysis tests of cores from the Olmos sand, Medina County, Tex., show that the Olmos crude autoignites in 90 p.s.i.a. oxygen at 425° F. The crude oil has a low coke laydown, and coke is needed to sustain a direct drive burn. Therefore, it is necessary to inject a supplementary fuel with a higher heating value to insure that the formation is heated sufficiently to dehydrate clays near the well bore in a near well burn stimulation treatment.

As an example, to practice this invention, steam at 1200 p.s.i.g., 575° F., would be injected for about 1½ days to preheat a 22 foot-thick reservoir. About 50 barrels of oil auto-ignitable below the steam temperature with high coke laydown would be injected through macaroni tubing to the area within a 5-foot radius from the well bore. Air would be injected down the steam line at 1200 p.s.i.g. to propagate the combustion zone to a 10–20 foot radius from the well bore. The resulting combustion temperature (over 1100° F.) would dehydrate clays, and consolidate the sand, resulting in increased permeability of the formation. Part of the injected oil and preheat value of the steam would be salvaged during backflow of the well.

Reasonable variation and modification are possible within the spirit and scope of the inveniton, the essence of which is a method of igniting an underground oil formation by injecting sufficient heated fluid into the formation to raise the temperature and pressure sufficiently high, so that, upon subsequently injecting a sufficient amount of auto-ignitable fuel, the fuel begins burning spontaneously when contacted by sufficient oxygen to support combustion.

We claim:

1. A method of igniting an underground oil formation comprising injecting sufficient heated fluid into said formation to raise the temperature and pressure thereof, above the ignition temperature of an auto-ignitable fuel at the pressure of said formation terminating the injecting of said heated fluid, subsequently injecting a sufficient amount of at least one auto-ignitable fuel into said formation, terminating the injecting of said auto-igniting fuel, injecting an oxygen-containing gas whereby said auto-ignitable fuel begins burning immediately in the presence of said gas.

2. The method of claim 1 wherein said gas is air.

3. The method of claim 1 wherein said heated fluid is steam.

4. The method of claim 1 wherein said fuel is selected from crude oil and mixtures of crude oil with tung oil, linseed oil, and tall oil.

5. A method of claim 4 wherein said fuel is crude oil.

6. The method of claim 1 wherein sufficient fuel is injected to saturate the reservoir within about a 5-foot radius of the well bore.

7. The method of claim 6 wherein sufficient oxygen-containing gas is injected to propagate the combustion zone to within a 20-foot radius of the well bore.

8. A method of dehydrating clay formations which comprises injecting sufficient heated fluid into said formation to raise the temperature and pressure of said formation above the ignition temperature of a fuel, saturating said formation with said fuel, and then injecting a gas containing sufficient oxygen to support the combustion of said fuel whereby said fuel auto-ignites and the formation is dehydrated by the burning of said fuel.

9. The method of claim 8 wherein said fluid is steam, said gas is air, and said fuel is crude oil.

10. The process of claim 9 wherein said fuel further contains at least one of the group comprising tung oil, linseed oil, and tall oil.

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