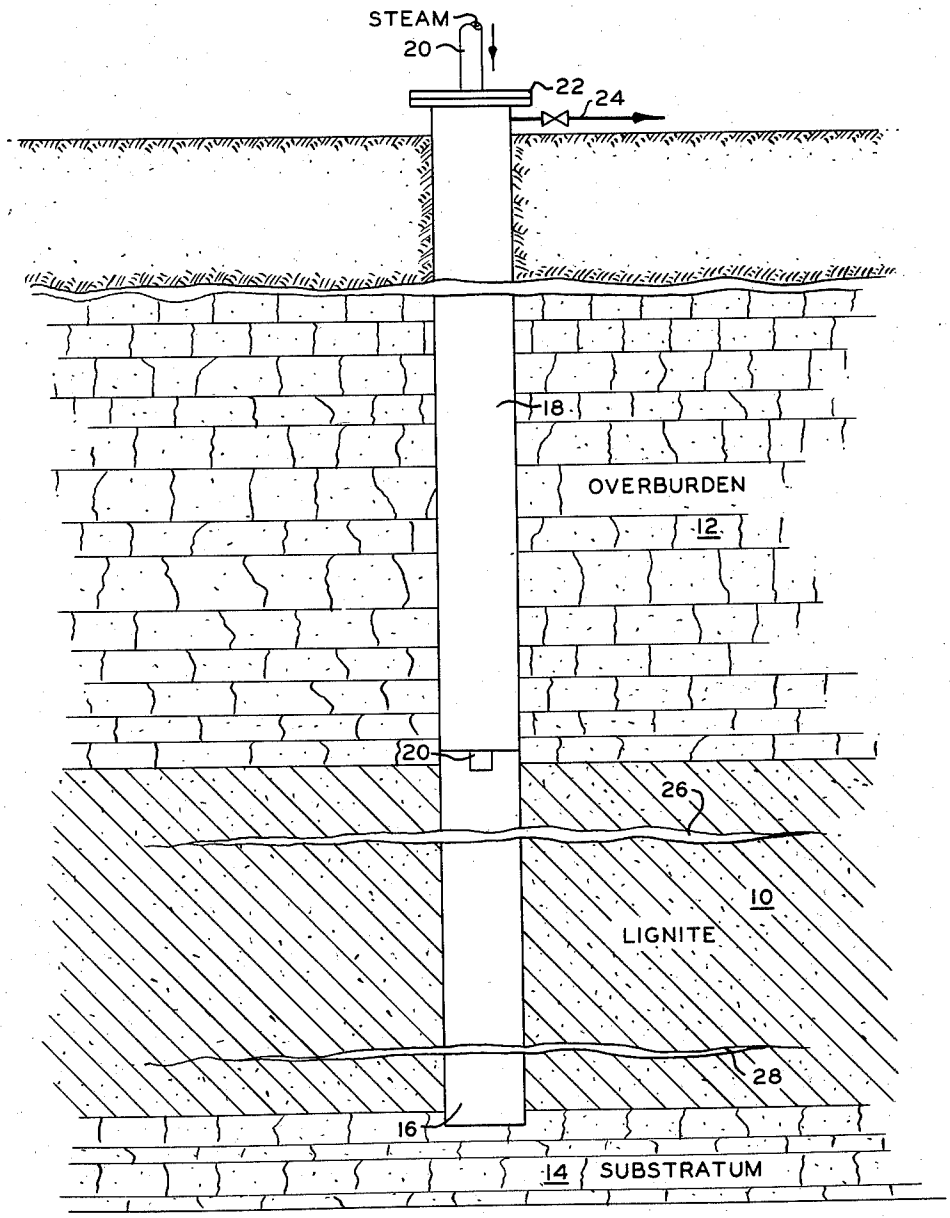
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IN SITU EXPLOITATION OF LIGNITE USING STEAM

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IN SITU EXPLOITATION OF LIGNITE USING STEAM

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This invention relates to a process for recovery of hydrocarbon material from lignite strata by in situ methods.

In situ combustion in the recovery of hydrocarbons from underground strata containing carbonaceous material is becoming more prevalent in the petroleum industry. In this technique of production, combustion is initiated in the carbonaceous stratum and the resulting combustion zone is caused to move thru the stratum by either inverse or direct air drive whereby the heat of combustion of a substantial proportion of the hydrocarbon in the stratum drives out and usually upgrades a substantial proportion of the unburned hydrocarbon material.

The ignition of carbonaceous material in a stratum around a borehole therein followed by injection of air thru the igition borehole and recovery of product hydrocarbons and combustion gas thru another borehole in the stratum is a direct air drive process for effecting in situ combustion and recovery of hydrocarbons from the stratum. In this type of operation the stratum usually plugs in front of the combustion zone because a heavy viscous liquid bank of hydrocarbon collects in the stratum in advance of the combustion zone which prevents movement of air to the combustion process. To overcome this difficulty and to permit the continued progress of the combustion zone thru the stratum, inverse air injection has been resorted to. By this technique, a combustion zone is established around an ignition borehole by any suitable means and air is fed thru the stratum to the combustion zone from one or more surrounding boreholes.

In situ combustion techniques are being applied to tar sands, shale, Athabasca sand and other strata in virgin state, to coal veins by fracturing, and to strata partially depleted by primary and even secondary and tertiary recovery methods.

Attempts have been made to produce lignite by in situ combustion but the permeability of the average lignite stratum is so low that production by in situ combustion is particularly difficult and impractical. This invention is concerned with a process for producing lignite strata which renders the lignite more permeable and simultaneously produces hydrocarbons therefrom before subjecting the same to in situ combustion.

Accordingly, it is an object of the invention to provide an improved process for producing hydrocarbon material from lignite strata. Another object of the invention is to provide a process which raises the permeability of a lignite stratum and simultaneously produces hydrocarbon material therefrom. A further object is to increase the rate of production of a lignite stratum by in situ combustion. Other objects of the invention will become apparent upon consideration of the accompanying disclosure.

A broad aspect of the invention comprises injecting saturated steam into a lignite stratum thru a well therein at sufficient pressure to fracture the stratum, continuing the injection of steam so as to heat a substantial annulus around the well to a temperature above vaporization temperature of water in the stratum at normal stratum pressure, suddenly releasing the steam pressure in the well so as to cause shattering of the stratum by flash vaporization of liquid therein, whereby hydrocarbon material released by the heating of the annulus flows into the well, and recovering the hydrocarbons so released. The sudden releasing of the steam pressure causes flash vaporization of condensed steam, connate water, and light hydrocarbon liquids and this sudden expansion and vaporization of these liquids shatters the lignite stratum, simultaneously producing chips and granules of lignite, some of which are produced in the well bore from which they are recovered by conventional means. The recovered lignite chips and granules may be steam distilled above ground to recover valuable hydrocarbon material therefrom.

The shattering of the lignite around the borehole enlarges the same considerably upon each heating and pressure release step so that by repeating the steam injection (heating) and pressure release steps a large injection cavity in the wellbore at the level of the stratum is produced which greatly increases the steam injection area and hastens the steam injection and heating process with a given steam pressure.

A preferred embodiment of the invention comprises applying the process just described to a pair of spaced apart wells, a central well in a ring-type pattern and in the wells of the ring, and in wells in two parallel lines of wells for a line-drive process. In this maner the spaced-apart wells are subjected to steam injection pressure, heating and flash vaporization and release of pressure with attendant shattering and production of distilled hydrocarbon material. The wells in the pattern utilized are positioned within fracturing distance from each other and fracturing is effected thru each of the wells so as to open up a steam passageway between wells. This technique permits venting one of the wells or one set of wells while injecting high temperature and high pressure steam thru the other well or set of wells so as to extend the heated volume of stratum between the wells, while distilling hydrocarbon material therefrom and rendering the same substantially more permeable.

After increasing the permeability of a large section of stratum between the wells or sets of wells, the remaining lignite around one well or set of wells is ignited by conventional means, such as by burning a fuel pack of charcoal or other solid fuel aggregates therein so as to heat the surrounding lignite to combustion-supporting temperature, and then contacting the hot lignite with combustion-supporting gas, such as air or air containing fuel gas in a concentration of about 1 to 3 volume percent. The fuel addition is essential when initiating combustion in the lignite by injection of the combustion-supporting gas in the injection wells to cause flow to the hot area at the ignition wells. After ignition of the stratum, the resulting combustion front is moved toward the other well or set of wells by direct drive by means of air injected thru the ignition wells or by inverse drive by means of air injected thru the wells opposite the ignition wells. When utilizing direct drive, produced gases are recovered thru the wells opposite the ignition wells and when utilizing inverse drive produced gases are recovered thru the ignition wells.

It is not necessary to remove the shattered lignite from the well in order to produce the lignite in accordance with the invention since the lignite chips, granules, etc., form a very permeable bed in the well cavity adjacent the stratum. However, the lignite stratum may be produced by intermittently pressuring the stratum with steam, releasing the pressure, removing the debris from the well and continuing the operation. In this manner a cavern

of considerable size is produced around a well. The recovered lignite particles are then subjected to distillation above ground. In this manner the process provides a means for producing a lignite stratum without a mine shaft and the equipment associated with recovery by this means.

The steam injection temperature to be used is at least 400° F. and preferably in the range of about 500 to 750° F.; and the pressure is in the range of 150 to 700 p.s.i.g. or higher, where greater fracturing pressures are required. Dry, superheated steam is preferred since greater heating is effected before condensation takes place. Heating an annulus of at least about 3 feet in radius adjacent the steam injection borehole to a temperature of at least 300° F. is sufficient to obtain the benefits of the invention but heating to a greater distance from the hole and to a higher temperature may be practiced to advantage before releasing the borehole presure. The second and successive heating and pressure release steps drive the heated zone farther into the stratum. Downhole heating by means of downhole heaters may be used to reduce condensation in the borehole and in the adjacent stratum either before or during steam injection.

In order to illustrate the invention, reference may be had to the drawing which is a schematic elevation thru a lignite stratum in which a producing well is disposed.

Referring to the drawing, a lignite stratum **10** is disposed between overburden **12** and substratum **14**. A well **16** passes thru stratum **10** and is cased by casing **18** substantially to the upper level of the lignite. Well **16** is also provided with a tubing string **20** extending thru well head **22** and a production line **24**. Fractures **26** and **28** are produced by injecting steam thru tubing **20** from any suitable source until the pressure within the stratum is sufficient to effect the fracturing. Fracturing at selected levels may be effected by conventional techniques in oil field production.

In accordance with the foregoing disclosure, steam is injected under pressure thru the resulting fractures into the lignite surrounding well **16** under pressure until a substantial section or annulus of the stratum is heated to at least 400° F. When this has been accomplished, pressure in the well and in the adjacent stratum is suddenly released, as by opening the valve in line **24**, so that shattering of the stratum is effected by flash vaporization of liquid therein. The hydrocarbons produced by the heating and vaporization are then produced from the well in conventional manner.

When utilizing a plurality of wells, as described hereinbefore, fracturing between wells is effected in similar manner which is then followed by heating with steam and flash vaporization.

Certain modifications of the invention will become apparent to those skilled in the art and the illustrative details disclosed are not to be construed as imposing unnecessary limitations on the invention.

I claim:

1. A process for recovering hydrocarbons from a subterranean lignite stratum which comprises injecting steam at a temperature of at least 400° F. into said stratum thru a well therein at sufficient pressure to fracture said stratum; continuing steam injection until a substantial annulus around said well is heated to substantially the steam temperature; thereafter, suddenly releasing the steam pressure in said well whereby shattering of said stratum is effected by flash vaporizing of liquid therein and hydrocarbons released by the heating of said annulus flow into said well; and recovering said hydrocarbons from said well.

2. The process of claim 1 wherein the steps of steam injection, heating, and pressure releasing are repeated.

3. The process of claim 1 wherein said shattering produces chips and granules of lignite and same are recovered from said well and steam distilled to recover hydrocarbon material therefrom.

4. A process for recovering hydrocarbons from a subterranean lignite stratum which comprises injecting steam at a temperature of at least 400° F. into said stratum thru a first well therein at sufficient pressure to fracture said stratum; continuing steam injection until a substantial annulus surrounding said first well is heated to a temperature of at least 300° F. and hydrocarbons are driven from said annulus, leaving same porous; thereafter, suddenly releasing the steam pressure in said well whereby shattering of said stratum is effected by flash vaporization of liquid in the porous stratum; performing the foregoing steps in a second well in said stratum spaced at least 10 feet from and sufficiently close to said first well that resulting fractures between the wells form a passageway for gases; shutting in said first well after steam begins to flow from said second to said first well so as to permit build up of pressure and additional heating of said stratum around said second well; thereafter, venting one of said wells and injecting steam in the other so as to release additional hydrocarbons from said stratum; and recovering said hydrocarbons from the vent well.

5. The process of claim 4 wherein said first well is a central well surrounded by a ring of said second wells each of which is operated as said second well.

6. The process of claim 5 wherein each said first and second wells is subjected to repeated pressure releasing and shattering steps to enlarge the injection cavity in the well and the chips and granules of lignite effected by the shattering are removed from the well prior to the venting and steam injection step.

7. The process of claim 4 wherein said first well is in a first line of wells and the other wells in said first line are treated in the same manner; said second well is in a second line of wells generally parallel with said first line of wells and the other wells in said second line are treated in the same manner; and steam is passed from the wells in one line to the wells in the other line.

8. The process of claim 4 including continuing the venting and steam injection until a substantial section of said stratum between said wells is produced sufficiently to render same permeable; igniting the remaining lignite around one of said wells; passing combustion-supporting gas to the resulting combustion zone thru one of said wells so as to move said zone thru said stratum toward the other well; and recovering produced hydrocarbons from one of said wells.

9. The process of claim 8 wherein said combustion-supporting gas is passed thru the well other than the ignited well to cause the combustion zone to move countercurrently to the gas and produced gases are recovered thru the ignition well.

10. The process of claim 8 wherein said combustion-supporting gas is passed thru the ignited well and produced gases are recovered thru the other well.

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