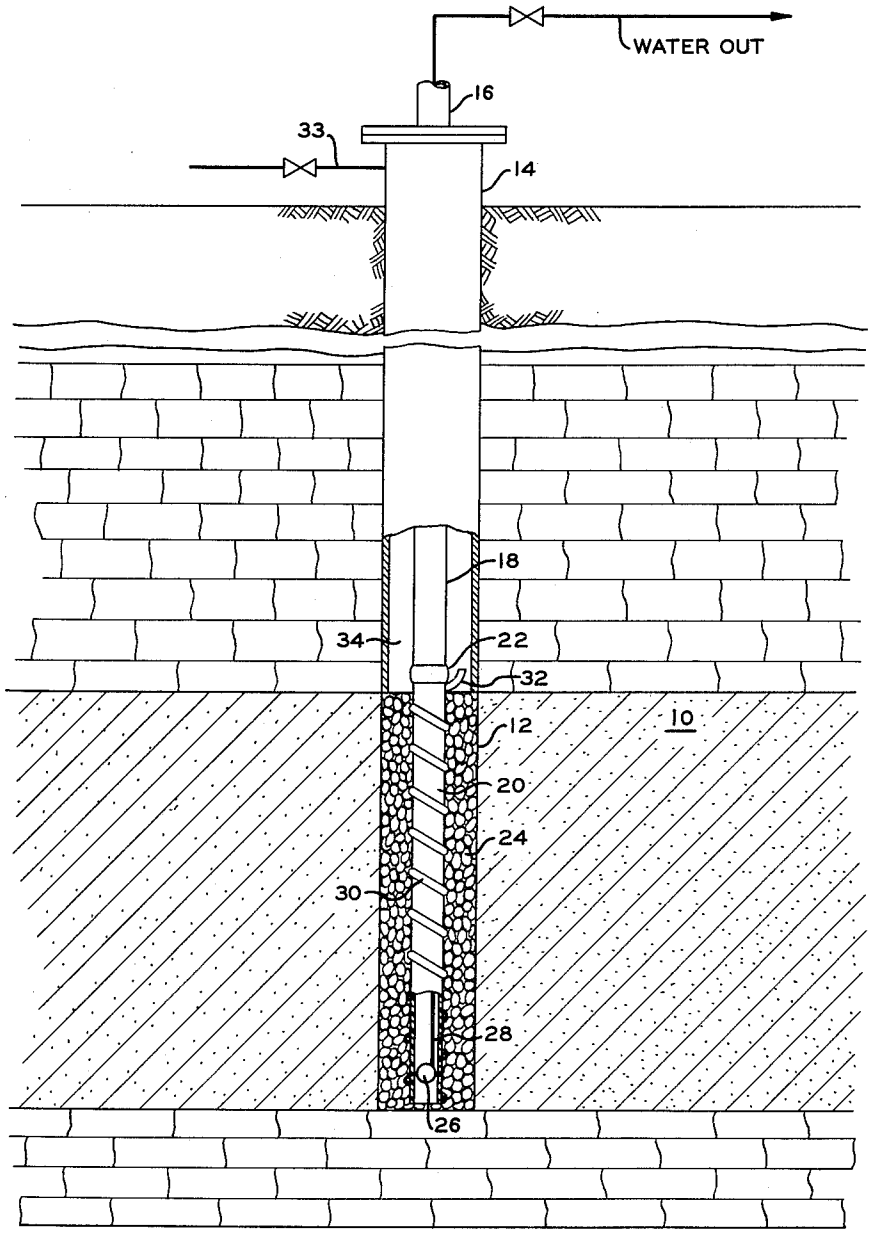
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APPARATUS AND PROCESS FOR IGNITING A STRATUM AROUND A WELL

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# APPARATUS AND PROCESS FOR IGNITING A STRATUM AROUND A WELL

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This invention relates to an apparatus and process for igniting a carbonaceous stratum around an ignition borehole.

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 of 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 ignition 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.

One successful method of igniting a stratum comprises placing a solid fuel pack in a well adjacent the stratum and burning the fuel pack with air to heat the surrounding stratum to ignition temperature so that it ignites when contacted with air. Field experience has shown that it is desirable to have a dry ignition well at the time of ignition when utilizing a fuel pack in this manner. This is particularly desirable when utilizing inverse injection of air thru the stratum into the well because of the flushing of water into the ignition borehole. It has been observed in the field that water may accumulate in the ignition and production well in a very short period of time even when the formation has been dried out by injecting air into the stratum prior to the ignition step. Since considerable time is consumed in packing the well with a fuel pack preparatory to ignition and burning thereof to ignite the stratum, water frequently collects in the well and wets the fuel pack, particularly, when the pack consists of charcoal briquettes, and this renders the ignition and combustion of the fuel pack difficult. This invention is concerned with a method of assuring a dry ignition well at the time of igniting the fuel pack therein.

A principal object of the invention is to provide an arrangement of apparatus and a process for igniting a fuel pack in an ignition well, while assuring dry conditions in the well at the time of ignition. Another object is to overcome the infiltration of water into an ignition well prior to the ignition step. Other objects of the invention



will become apparent upon consideration of the accompanying disclosure.

In accordance with the invention, a tubing string having a combustible section on its lower end is run in an ignition well so that the end of the non-combustible upper section terminates at a locus adjacent the upper level of the stratum to be ignited and produced. The combustible tubing section is fabricated of any suitable material such as magnesium, plastic, hard rubber, laminated wood, etc. A fuel pack of solid fuel, such as charcoal briquettes, porous ceramic pieces soaked with heavy fuel oil, a mixture of ceramic pieces and charcoal pieces both soaked with heavy fuel oil, and the like, is disposed in the well within the stratum to be produced and extending at least to the upper level thereof, thereby forming an annulus around the combustible section of well tubing. In this manner any water which collects in the bottom of the well is readily forced out thru the tubing by injecting air or other flushing gas thru the stratum from offset wells and producing the injected fluid thru the well tubing. This is done just before the ignition step so that the fuel pack is substantially dry. As the fuel pack is ignited and burned, the combustible tubing section is also consumed by burning. This avoids the presence of junk tubing in the ignition borehole and positions the inlet end of the production tubing at the desired level adjacent the top of the stratum.

To provide a more complete understanding of the invention, reference is made to the accompanying schematic drawing which is an elevation in partial section of a preferred embodiment of the invention. Referring to the drawing, a combustible carbonaceous stratum **10** is penetrated by a borehole **12** which is provided with a casing **14** extending to about the top of stratum **10**. A tubing string **16** comprising an upper metal (preferably iron or steel) section **18** and a lower combustible section **20** extends thru the well head to the bottom of the well. Section **20** is attached to the non-combustible section **18** by means of a suitable collar **22** which may be either combustible or non-combustible as desired. A charcoal or other fuel pack **24** forms an annulus around combustible tubing **20** and extends to the top of the stratum. A butterfly or other type of valve **26** is positioned in the lower end of combustible tubing section **20** in open position with a wire or cable **28** extending from a spiral spring around the shaft of the valve up to the upper end of section **20** where it is anchored either in the end of the tubing or in collar **22** attached thereto. An igniter **30** in the form of a spiral fusee encircling combustible section **20** terminates with its upper end **32** above the fuel pack for quick ignition. A line **33** connects with the upper end of casing **14** and with the casing-tubing annulus **34**.

In operation, the well is dried out preferably by injecting air thru offset wells surrounding well **12** and producing water and the injected air thru well **12**. This drying step may be effected before or after running tubing string **16**. In either event, it is preferred to inject air thru the stratum into well **12** after running tubing string **16** and just before lowering the charcoal or other fuel pack into the annulus around tubing section **20**. In applications in which stratum **10** is thick and a substantial period of time is consumed in positioning the fuel pack in the well, it is desirable to inject air thru stratum **10** into the well so as to force any water which may have collected in the bottom of the well out thru tubing string **16**. It is also feasible just before ignition to inject air thru the tubing-casing annulus via line **33** so as to drive water from the bottom of the well out thru tubing string **16**.

After drying out the bottom of the well the fuel pack is immediately ignited by any suitable method such as by dropping 20 to 30 pounds of hot charcoal down the

casing-tubing annulus or by dropping a railroad fusee or other self-combustible device in lighted condition down the annulus onto the top of the fuel pack. This method is effective without the use of igniter 30, since the hot charcoal or the hot burning fusee heats the top layer of charcoal so that injection of air either thru line 33 or thru the stratum from offset wells feeds air to the hot charcoal and causes ignition and combustion thereof. Combustion of the upper end of the fuel pack ignites the combustible tubing section 20 so that this section of tubing burns and is consumed as the fuel pack is burned. In some instances the combustible section of tubing burns more rapidly than the charcoal and, by this means, combustion of the fuel from top to bottom of the pack is effected so that injection of air thru the stratum into the ignition well moves the combustion zone radially outwardly thru the fuel pack and eventually into the stratum to establish in situ combustion therein.

By utilizing an igniter in the form of a spiral wrap, such as 30 in the drawing, the combustion is rapidly extended from the end 32 of the igniter to the bottom end of the fuel pack, upon igniting end 32 as by dropping a fusee down the annulus or by igniting end 32 by means of an electric sparking device (not shown). Igniter 32 may comprise any self-contained ignition material having its own oxygen supply, such as gun powder, enclosed in a combustible wrapping or cover. This igniter may extend only a portion of the length of the tubing section 20 in instances where only the upper section of fuel pack is to be ignited.

In igniting the upper end of the fuel pack the upper end of combustible tubing section 20 will be burned off and this leaves a temporary chimney extending from the bottom of the well up to the burning end of the tubing section for air to bypass the charcoal pack. In order to prevent this by-passing of air, a butterfly or other type valve 26 is set to close upon releasing of cable or wire 28 at the upper end of the tubing section 20 when the same is consumed by the combustion in the upper end of the fuel pack. It is also feasible to omit valve 26 and to drop any combustible plugging material down the tubing string to the bottom of the hole when the water has been driven out thru the tubing and the ignition step is to be effected. An epoxy resin or any other sealing material can be dropped thru the tubing to effect the plugging in the end thereof so as to prevent air by-passing the fuel pack when inversely injected thru the stratum.

In order to move the combustion zone from the fuel pack into the surrounding adjacent stratum by inverse air injection, it is essential to incorporate in the injected air a small concentration of fuel gas, such as propane or any normally gaseous hydrocarbon or mixtures thereof, in the injected air. The concentration of fuel gas in the injected air is usually in the range of 1 to 4 percent by volume. This fuel gas may be incorporated in the air feeding the fuel pack; or addition of the fuel gas to the air may be commenced so that it arrives at the ignition borehole in admixture with the injected air when the temperature of the stratum surrounding the fuel pack and adjacent same has been raised to ignition temperature.

After combustion of the upper end of tubing section 20, produced gases, including combustion gas and hydrocarbon gases driven from the stratum, are produced thru tubing string 16 into which they enter thru the lower end of section 18, section 20 having been burned off at collar 22.

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. In combination in a well extending into a combustible carbonaceous stratum, a tubing string in said well extending from the well head into said stratum, the lower end of said string within said stratum being open to said well, the section of said string within said stratum being fabricated of combustible material and its upper portion above said stratum being fabricated of non-combustible material so that when the hereinafter defined fuel pack is burned, the lower end of said string is consumed by burning; and a combustible permeable solid fuel pack surrounding the lower combustible end of said string.



2. The combination of claim 1 wherein said fuel pack comprises charcoal.

3. The combination of claim 1 wherein said fuel pack comprises porous ceramic pieces soaked with heavy hydrocarbon oil.

4. The combination of claim 1 wherein said combustible end is fabricated of magnesium.

5. The combination of claim 1 wherein said combustible end is fabricated of hard rubber.

6. The combination of claim 1 wherein said combustible end is fabricated of plastic.

7. The combination of claim 1 including a self-contained igniter adjacent the upper end section of the combustible tubing.

8. The combination of claim 7 wherein said igniter extends substantially the length of said combustible tubing.

9. The combination of claim 8 wherein the igniter spirals around said combustible tubing and extends to a point above said fuel pack.

10. A process for igniting a combustible carbonaceous stratum around an ignition well therein in which water collects at the bottom of the well comprising setting a tubing string to the bottom of said well, the lower end of said string within said stratum being readily combustible and the remainder being non-combustible; placing a combustible fuel pack around the lower combustible end of said string adjacent said stratum; forcing air thru said stratum into said ignition well from at least one offset well so as to force water from the bottom of said ignition well out thru said tubing string; thereafter igniting said fuel pack and burning same along with said combustible lower end of said string so as to heat the adjacent surrounding stratum to ignition temperature; injecting combustion-supporting gas into the hot stratum so as to ignite same; and withdrawing produced and combustion gases thru the non-combustible section of said string.

11. The process of claim 10 wherein said fuel pack is ignited at the top and combustion-supporting gas including fuel gas in the range of about 1 to 4 volume percent is injected thru said stratum into the ignition borehole to burn said pack and extend the combustion zone into said stratum.

12. The process of claim 10 wherein said pack and the combustible section of said string are ignited by burning a self-sustaining igniter on the upper end of said section.

13. The process of claim 10 wherein the combustible section of said string is ignited by burning an igniter along said section from end to end so as to simultaneously ignite said fuel pack; and passing air admixed with from 1 to 4 volume percent of fuel gas to the ignited area thru said stratum, so as to move the resulting combustion zone radially thru said pack and into said stratum.

14. The combination of claim 1 including means for igniting said fuel pack and means for closing the lower end of the combustible section of said tubing string.


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