

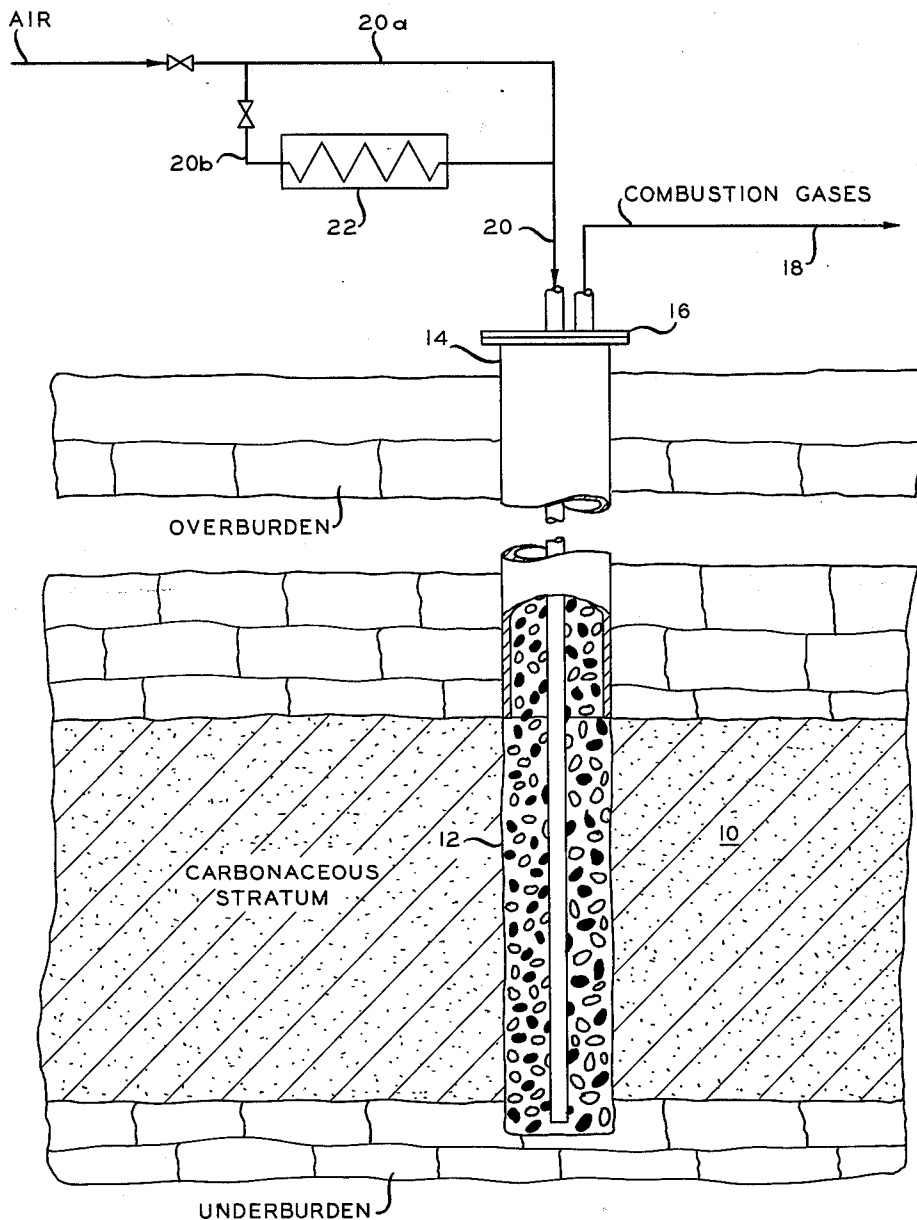
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IN SITU COMBUSTION INITIATION

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- CHARCOAL BRIQUETS
- HYDROCARBON-POLYMER BRIQUETS

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IN SITU COMBUSTION INITIATION

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This invention relates to a process or method for initiating and establishing in situ combustion in a permeable carbonaceous stratum.

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 through the stratum by either inverse or direct air drive whereby the heat of combustion of a substantial portion of the hydrocarbon in the stratum drives out and, in the case of inverse drive, upgrades a substantial portion of the unburned hydrocarbon material.

Whether using a direct air drive or an inverse air injection in situ combustion process it is first necessary to ignite the carbonaceous stratum around a borehole therein before a combustion front can be caused to move through the stratum. It is difficult to establish a self-sustaining combustion in many carbonaceous strata and in establishing such a combustion zone certain problems have arisen.

The process of the invention is concerned with a method of initiating self-sustaining in situ combustion in a carbonaceous stratum whereby many of the prior art difficulties normally associated with in situ combustion initiation are obviated.

Accordingly, an object of the invention is to provide a process for initiating and establishing in situ combustion in a carbonaceous stratum.

A further object is to provide a process which establishes a deep and substantial self-sustaining combustion front around an ignition borehole.

Another object of the invention is to provide a fuel pack for initiating in situ combustion in a carbonaceous stratum.

Other objects, aspects, as well as these several advantages of the invention will become apparent from consideration of the accompanying disclosure and the appended claims.

In accordance with the invention, the objects are achieved by employing as a combustion initiating material a combustible solid ignition composition comprising a normally solid polymer of a 1-olefin, a trans diene polymer of a conjugated diene, and mixtures thereof, and a normally liquid hydrocarbon.

Further according to the invention, the above objects are achieved by employing as a combustion initiation material a gas permeable fuel pack of (1) a solid combustible material, such as charcoal, and (2) a combustible solid ignition material comprising a normally solid 1-olefin polymer, a trans diene polymer, and mixtures thereof, and a normally liquid hydrocarbon. It is also within the scope of the invention to employ a granular refractory material along with the above described ignition composition or in place of the solid combustible material. The inclusion of the granular refractory material in the mixture renders the mixture porous, permitting flow of the air or other combustion supporting gas through the fuel pack and to the formation to support combustion therein after initiation, and provides a heat absorbent to maintain the air or gas passing through the fuel pack at a high temperature.

A broad aspect of the process of the invention comprises placing in an ignition borehole in a carbonaceous stratum a substantial mass of a combustible solid ignition

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material comprising a normally solid 1-olefin polymer, a trans diene polymer, and mixtures thereof, and a normally liquid hydrocarbon alone or in admixture with combustible particulate material and/or particulate refractory material, igniting the combustible solid ignition material, passing combustion-supporting gas through the ignited fuel pack so as to continue combustion of said ignited pack, thereby heating and igniting a section of the stratum adjacent the burning fuel pack.

Suitable solid particulate combustible materials that can be employed along with the solid combustible ignition material of the invention include petroleum coke, coke from coal, charcoal, coal, wood and other solid combustible carbonaceous materials. Generally, the combustible material should have a particle size as small as possible compatible with retention in the fuel pack under the rates of flow of the air or other combustion-supporting gas through the fuel pack. The amount of solid combustible carbonaceous material in the combustion initiation fuel pack can vary appreciably, but ordinarily a sufficient amount of the carbonaceous material will be used to raise the temperature of the fuel pack sufficiently high to initiate combustion of the surrounding carbonaceous stratum. Generally, the amount of combustible carbonaceous material employed will be in excess of about 10 percent by weight of the ignition mixture or fuel pack, although this amount will vary with the type of combustible material and the particular ignition material utilized. As indicated above, it is within the scope of the invention to employ the solid combustible ignition material alone to initiate combustion in a borehole. The granular refractory materials or propping materials that can be employed in the fuel pack of the invention can be crushed or broken stone, pebbles, sand, crushed or broken firebrick, consolidated particles of clay, etc. The essential characteristic required of these materials is that they are of such size and shape that they will not pack to form a body impermeable to the flow of air or other gas therethrough for supporting combustion within the fuel pack and the borehole. The carbonaceous bodies and refractory bodies can be dry or saturated with a liquid hydrocarbon fuel which extends the burning life of the fuel pack.

As indicated above, a solidified combustible igniting composition comprising a normally solid 1-olefin polymer, a trans diene polymer, or mixtures thereof, and a normally liquid hydrocarbon is provided. The polymer portion of the solidified igniting composition of the invention comprises one of the high molecular weight 1-olefin polymers obtained by polymerizing 1-olefins having from 2-8 carbon atoms per molecule, a trans polymer obtained by polymerizing a conjugated diene having 4-5 carbon atoms, and mixtures thereof.

The term "polymers of 1-olefins" includes homopolymers of 1-olefins as well as copolymers of 1-olefins with each other. Representative examples of suitable 1-olefins include ethylene, propylene, butene-1, pentene 1, hexene-1, 4-methylpentene-1 and the like. Suitable 1-olefin polymers that can be employed include polyethylene, polypropylene, poly-1-butene, poly-1-pentene, and the like as well as copolymers of ethylene with minor amounts, generally 5 percent or less, of propylene, 1-butene, 1-hexene, butadiene, isoprene and the like. The preferred ethylene polymers have a density ranging from 0.93 to 1.0, preferably 0.94 to 0.98. The preferred polypropylenes and poly-1-butenes have an isotactic content of at least 75 percent. The more preferred polymers are polyethylene and particularly polyethylene having an average molecular weight greater than about 100,000 as determined from inherent viscosity (also known as particle "particle form" polymer). The "particle form" polyethylenes ordinarily have an inherent viscosity ranging from 3 to 10

and a high load melt index (ASTM D-1235-57T—procedure F) ranging from 0.6 to 10.

The trans diene polymers that can be used in the solidified igniting composition of the invention include high trans-polybutadiene, high trans-polyisoprene, high trans-polypiperylene, and naturally occurring polymers of high trans-content, such as balata and guttapercha. The trans diene polymers ordinarily have at least 70 percent of their molecular structure in a trans-1,4-configuration, preferably at least 85 percent of the polymer formed by trans-1,4-addition of the conjugated diene.

The above 1-olefin polymers and trans diene polymers can be prepared using any suitable polymerization procedure by which such structures and polymers can be obtained. The olefin polymers can be prepared by any of the known solution processes as well as the "particle form process" (polymerization of 1-olefin is carried out in suspension and below temperature at which any substantial portion of the polymer formed is in solution in the suspension medium). One convenient process for the production of trans-diene polymers involves solution polymerization of a conjugated diene having 4-5 carbon atoms in the presence of an initiator system comprising lithium aluminum hydride and titanium tetraiodide. Polymers prepared in this manner will ordinarily contain 90 percent or more of materials of trans-1,4-configuration.

It is also within the scope of the invention to employ polymer mixtures in all proportions of the 1-olefin polymers and trans-diene polymers in forming the solid combustible igniting compositions. The mixture of trans-diene polymer and 1-olefin polymer can be made by conventional dry blending of the polymers after which the polymer blend is incorporated in the liquid hydrocarbon described hereinbelow, or the two polymers can be sequentially or simultaneously added separately to the liquid hydrocarbon.

The normally solid polymers or polymer blends described above are blended with normally liquid hydrocarbons or hydrocarbon mixtures or fuels which boil as low as hexane and as high as heavy cycle oils, i.e., from about 100° F. to about 900° F. to provide the solid combustible igniting compositions of the invention. Ordinarily, liquid hydrocarbons boiling from about 200 to about 700° F. are preferred. Hydrocarbons that can be utilized include saturated and unsaturated acyclic, saturated and unsaturated cyclic and aromatic hydrocarbons, or combinations or mixtures thereof. Petroleum refinery hydrocarbon fractions such as gasolines, kerosenes, stove oils, furnace oils, gas oils, cycle oils, diesel oils, crude oil, topped crudes, and the like are especially useful for preparing the solid ignition compositions of the invention. Hydrocarbon fractions having flash points ranging from about 100 to about 250° F. are usually preferred. Hydrocarbons or mixtures most preferred are those boiling between about 300 and about 500° F., e.g., alkylate fractions.

The proportions of hydrocarbon and polymer employed for preparing the solid ignition compositions of the invention depend upon the nature of the hydrocarbon and more particularly upon the nature of the polymer employed. In general, the solid combustible ignition composition will contain a minor proportion of polymer or polymer blend, generally from about 4 to about 40 weight percent of polymer or polymer blend, preferably from about 5 to about 20 weight percent of polymer or polymer blend, and the remainder of the composition being a normally liquid hydrocarbon as defined above. Thus, the amount of liquid hydrocarbon present in the solid ignition composition ordinarily ranges from 96 to 60 weight percent, more often from about 95 to 80 weight percent. The hydrocarbon polymer ignition compositions prepared according to the invention ordinarily have a gross heat of combustion ranging from about 20,000 to about 21,000 B.t.u./lb.

It is also within the scope of the invention to improve the form stability of the above defined solid ignition compositions of solid polymer and liquid hydrocarbon by incorporation therein from 5 to about 20 weight parts, based on 100 weight parts of combustible ignition composition, of at least one finely divided substantially anhydrous pyrogenic oxide selected from the oxides of Al, Zr, Ti and Si. The addition of the finely divided pyrogenic oxides substantially extend the versatility of the solid ignition fuels formed from normally liquid hydrocarbons and normally solid polymers as described herein. The addition of the finely divided pyrogenic oxide renders the solid fuel composition form-stable throughout the burning period. Flow of fuel from the burning site or sticking to the environment does not occur and burning of the fuel is substantially complete. By finely divided pyrogenic oxide is meant non-hydrated and substantially anhydrous (i.e., not over about 5 percent volatile matter) oxides having an average discrete particle size of not more than 100 millimicrons, preferably less than 50 millimicrons, and produced by vapor phase hydrolysis or oxidation of compounds of the corresponding metals and/or metalloids.

It is also within the scope of the invention to employ burning rate accelerators such as magnesium, aluminum, etc., in finely divided form incorporated into the solid ignition composition of the invention, i.e., solid polymer and liquid hydrocarbon, or in the solid combustible carbonaceous materials such as charcoal, coke, etc.

In the exercise of the invention, the ignition composition of liquid hydrocarbon and polymer or polymer blend and other additives, when desired, are brought together in a vessel or other suitable apparatus and blended at a temperature and for a sufficient length of time to yield a homogeneous mixture. The temperature employed should be kept below that at which any appreciable degradation occurs. Temperatures of 10 to 60° C. above the melting point of the polymer or polymer blend have been most satisfactory for the blending operation. The temperature employed during the blending will vary depending upon the polymer employed, i.e., olefin polymer or trans-diene polymer or a mixture of the two in the polymer portion of the composition. However, in general, the temperature utilized will range from about 40 to about 160° C. and if this temperature is above the boiling point of the hydrocarbon, the operation is preferably carried out in a pressurized vessel to maintain the components substantially in the liquid state. Blending of the polymer(s), hydrocarbon and other additives, according to the invention, can be carried out under batch, semi-continuous or continuous conditions using suitable equipment therefor.

After homogenization is complete, the mixture of polymer(s), hydrocarbon and other additives, is allowed to cool and solidify, preferably without agitation. It is generally desirable to transfer the hot and still fluid product to a more convenient location before solidification begins where the desired geometrical shape of the finished product can be obtained. The solidified polymer-hydrocarbon composition, according to the invention, can be cast or molded into pellets, discs, briquets, spheres, cubes, logs, twigs or bars or any shape possible with a hot viscous liquid and in any size depending upon apparatus available and its capacity for heating, cooling and handling. When desired, the solid ignition composition of the invention can be extruded as rods or cylinders and cut into discs or other shapes of suitable sizes. When a mold is used, it is frequently desirable to preheat the mold in order to prevent premature hardening before the desired shape is obtained.

It is also within the scope of the invention to impregnate and coat solid carbonaceous bodies, e.g. charcoal briquets, or solid refractory bodies with the solid ignition hydrocarbon-polymer composition of the invention. The treatment of solid carbonaceous bodies or refractory bodies

can be carried out purely mechanically by any desired method of application, as for example, by spraying or immersing in a hot bath of the homogeneous liquid mixture of hydrocarbon and polymer so long as the exterior surfaces of the bodies are covered by a relatively thin film or skin of the hydrocarbon-polymer composition. Ordinarily, it is preferred to immerse the solid carbonaceous body or refractory body into the liquid hydrocarbon-polymer solution, which is at a temperature above the melting temperature of the polymer, for a time sufficient to impregnate the body with the igniting composition and provide the outer surface with a thin film of the liquid. After the solid body has been treated with the solidifiable ignition composition, it is allowed to cool below the softening temperature of the polymer so as to solidify a thin film around the fuel body.

Upon the completion of the coating of the solid carbonaceous or refractory body, portions of the liquid hydrocarbon-polymer composition covering the body will have penetrated into and around the porous absorptive structure of the charcoal, for example, during the coating operation, and in so doing will result upon cooling in the solidification of a continuous coating and sealant of the composition on the briquet in the form of a relatively tight skin or film adhering and following the surface contours of the briquet and sealing porosity. It is generally desirable to transfer the coated fuel body to a more convenient location where solidification of the hydrocarbon-polymer igniting composition takes place and the finished product is obtained.

In carrying out the invention in actual practice, a gas permeable fuel pack comprising (1) solid ignition material comprising liquid hydrocarbon-polymer alone or (2) in admixture with particulate combustible carbonaceous material and/or particulate refractory material is placed in a borehole in a carbonaceous stratum which it is desired to ignite. The fuel pack can be dumped into the borehole from the surface or lowered into the borehole in a suitable container or in any other manner desired. Generally, a sufficient amount of ignition material should be employed to fill the borehole along the entire depth of the formation in which combustion is to be initiated in order to obtain firing of the formation along the entire face exposed to the borehole. However, the combustion initiation material or fuel pack can be placed in the well or borehole to form a column of any length greater or smaller than the thickness of the formation exposed to the borehole and it is often advantageous to form a column of combustion initiating material greater than the length of the formation exposed to the borehole and extending upwardly beyond the formation since thereby the problems of igniting the combustion initiating material, increasing with depth, are minimized.

Ignition of the fuel pack can be effected in a number of ways, for example, the fuel pack can be ignited at the surface and the ignited pack then positioned in the borehole adjacent to the formation in which combustion is to be initiated, a supply of air or other combustion-supporting gas being pumped or otherwise injected in the borehole to maintain combustion in the fuel pack and in the formation after combustion is initiated. Preferably, however, the fuel pack is placed or positioned in the borehole adjacent to the formation and the fuel pack thereafter ignited, the supply of air or other combustible gas being provided to maintain combustion in the fuel pack and in the formation after ignition.

Various methods can be employed to ignite the fuel pack after the fuel pack has been positioned adjacent to the formation. For example, a package of solid polymer and hydrocarbon can be ignited at the surface and then placed in the well on top of the fuel pack already in the well. Another method, which is presently preferred, comprises heating the air or other combustion supporting gas injected into the borehole to a temperature above the ignition temperature of the solid combustible ignition com-

position of polymer and liquid hydrocarbon in the fuel pack whereby the hydrocarbon portion of the fuel pack will ignite. Rapid ignition can be obtained by this method where the injected air or other combustion-supporting gas is heated to a temperature of at least about 750° F. As solid combustible carbonaceous material and solid ignitor burn in the fuel pack more solid combustible carbonaceous material, e.g., charcoal, and ignitor can be added through a "lubricator" at the top of the borehole. As indicated previously the size of the particles in the fuel pack is such that it gives sufficient air permeability to the fuel pack and the formation during the ignition and subsequent combustion stage.

Ignition of the fuel pack after positioning in the well bore can also be effected by suspending a burner in the hole above the formation or a railroad fusee dropped onto the fuel pack in the hole from the ground or surface above. After ignition of the fuel pack, air or other combustion-supporting gas is passed through the fuel pack so as to continue combustion of the ignited fuel and at the same time heat and ignite a section of the stratum adjacent the burning fuel pack. Heated air or other combustion-supporting gas or hot air produced by a downhole heater can be used to cause autoignition of the liquid hydrocarbon-polymer ignition composition when the air temperature reaches 750° F. This feature of the invention is quite advantageous over hydrocarbon soaked solid carbonaceous or combustible refractory materials alone which will not autoignite. By properly distributing the liquid hydrocarbon-polymer ignition composition throughout the fuel pack, the ignition will be uniform from top to bottom of the formation. If desired the ignition material of hydrocarbon and polymer can be placed only at the bottom, near the middle, or at the top of the ignition pack.

Ignition can also be effected by placing a charge of black powder or other readily combustible, low brisance material, containing its own combustion supporting medium on top of the fuel pack and igniting electrically, by fuse, or otherwise. Other methods of ignition will suggest themselves to those skilled in the art.

One practical method of practicing the invention comprises inserting production tubing to the bottom area of the borehole before introducing the fuel pack thereto so that after the fuel pack is positioned an incendiary device such as a railroad fusee or similar means, e.g., hot air at a temperature of at least about 750° F., capable of self-ustaining combustion is passed down the tubing into the fuel pack thereby igniting a substantial area in the bottom of the fuel pack. In order to facilitate the initial phase of the ignition a void space can be provided at the end of the tubing by any suitable means such as by raising the tubing a short distance after the fuel pack is in place and just before ignition of the fuel pack so that the burning fuel pack is outside the tubing. Other methods of igniting the fuel pack can be utilized such as by positioning at the bottom of the borehole and fuel pack an electrical heating element or an incendiary device with a fuse running to ground level or even to the top of the pack where it can be ignited by dropping a burning material onto the top of the pack or by hot air.

When utilizing the production tubing extending to the bottom section of the fuel pack, it is preferable to inject air through the tubing into the bottom of the pack to feed the combustion and drive the same upwardly through the pack by direct drive. This procedure can be supplemented by injecting air through one or more offset wells and driving the same through the stratum to the ignition well. Upon entering the ignition well the inverse air thus injected assists in the combustion occurring in the fuel pack. It is also within the scope of the invention to utilize the inverse air as the sole air supply for the burning of the fuel pack, but when operating in this manner, the effluent gas from the burning fuel pack is usually withdrawn from the annulus surrounding the production tubing unless the production tubing is withdrawn so that its

lower end is above the fuel pack or at least in the upper portion thereof. It is also within the scope of the invention to pass hot air, for example, at a temperature above 750° F. down through the annulus to ignite the top of the fuel pack surrounding the tubing and initiate burning on top of the fuel pack and remove the combustion gases from the borehole through the tubing extending to the bottom of the borehole.

A preferred ignition fuel pack comprises a mixture of particulate ignition material comprising liquid hydrocarbon and polymer and charcoal briquets packed into the ignition borehole from the bottom level of the stratum to the top thereof. Charcoal and ignition fuel in any form can be utilized in the fuel pack so long as the fuel pack mass is gas permeable. One particularly desirable arrangement comprises a perforate section of tubing within the stratum connecting with an imperforate tubing string above the stratum, with an annular mass of fuel pack surrounding the perforate tubing. The perforations in the tubing should of course be smaller than the particulate particles of the fuel pack so as to avoid blowing the particles out through the tubing when combustion supporting gas is injected into the borehole from the surrounding stratum, for example, and combustion gas is vented up the borehole.

One advantage of the invention is that considerably more combustible hydrocarbon for ignition of the fuel pack and the formation can be provided, according to the invention, than can be provided by soaking charcoal briquets, for example, with hydrocarbon. Another advantage of the invention lies in the fact that it is only necessary to raise the temperature of the combustion air to about 750° F. to bring about spontaneous combustion of the ignition hydrocarbon-polymer fuel of the invention. Thus, by the invention ignition of deep wells without encountering the problems of dropping incendiary bombs, etc. into the drill hole can be achieved. A more complete understanding of the invention may be had by reference to the accompanying schematic drawing which is an elevation in partial section of an arrangement of the fuel pack in a borehole in a carbonaceous stratum to be ignited.

Referring to the drawing, a combustible carbonaceous stratum 10 is penetrated by an ignition well 12 which is provided with a casing 14 extending to the approximate upper level of the stratum. Casing 14 is provided with a wellhead 16; and a production combustion gaseous outlet 18. An air inlet 20 extends through wellhead 16 to near the bottom of the borehole 12. Air from a suitable source enters conduit 20 through conduits 20a and/or 20b communicating therewith. Valves are provided in conduits 20a and 20b to regulate the flow of air through each. Heater 22 is positioned around conduit 20b to provide for obtaining the desired temperature of the air to be introduced through conduit 20 to the wellbore. Wellbore 12 is filled with a fuel pack comprising charcoal briquettes and hydrocarbon-polymer briquettes. The fuel pack extends across the depth of the carbonaceous stratum 10. As hot air is introduced through conduits 20a and 20b into the bottom of wellbore 12 it contacts the fuel pack and immediately ignites the hydrocarbon-polymer briquettes which ignites the charcoal briquettes and as the fuel pack burns upwardly the carbonaceous stratum is ignited. After the fuel pack is ignited air is introduced through conduit 20a to conduit 20 for continuing the combustion of the fuel pack and carbonaceous stratum.

A better understanding of the invention can be obtained by referring to the following illustrative example which is not intended, however, to be unduly limitative of the invention.

Specific example

An igniting composition is prepared by blending together a high molecular weight polyethylene and an isoparaffinic hydrocarbon fraction at a temperature above the melting point of the polyethylene. A 16.0 g. quantity

of "particle form" high density polyethylene is blended with 75.33 g. of Soltrol 170 (isoparaffinic hydrocarbon) at about 150° C. for 3-5 minutes with continuous stirring. The polyethylene is a high molecular weight polymer with an inherent viscosity of 4.76 and a melt index (high load) of about 1.06. This polymer is in the form of a granular solid obtained by a particle form process in a low pressure polymerization process over a chromium oxide-containing catalyst. The particle form process is a process in which polymerization of 1-olefins is carried out in suspension and below the temperature at which any substantial portion of the polymer formed is in solution in the suspending medium. Soltrol 170 is a commercial isoparaffinic hydrocarbon fraction with a boiling range of 420 to 475° F. The aromatic content of this fraction is nil and the specific gravity is about 0.775.

The hydrocarbon and polymer are blended together at the elevated temperature until the mixture appears homogeneous. The essentially clear hot mixture, upon cooling to room temperature, forms a hard tough solid composition having a heating value of 20,123 B.t.u.'s per pound. The hydrocarbon-polymer composition is formed into spherical briquets 1 inch in diameter weighing 5.2 grams and containing 92.5 weight percent isoparaffinic hydrocarbon and 7.5 weight percent polyethylene.

A fuel pack comprising charcoal briquets and hydrocarbon-polymer briquets is placed around tubing in the bottom of an ignition borehole in an oil bearing formation. The ratio of charcoal briquets to hydrocarbon-polymer briquets in the fuel pack is about 25:1. The fuel pack extends from the bottom of the hole to the top of the formation being ignited. Heated air at a temperature of about 800° F. is passed down the tubing and up through the porous fuel pack surrounding the lower portion of the tubing. The hot air ignites the hydrocarbon-polymer briquets almost immediately. After ignition of the hydrocarbon-polymer briquets is effected, atmospheric air is passed down the tubing and up through the fuel pack so as to continue combustion of the ignition briquets and to ignite the charcoal briquets and the adjacent carbonaceous formation. Hot combustion gases are withdrawn from the well through the annulus surrounding the tubing.

After ignition of the formation is achieved by the burning fuel pack, air injection can be continued in the ignition well and production of oil obtained through offset wells by causing the combustion zone to move through the oil bearing stratum by direct air drive. If desired, the ignition well can be used as the production well and air can be injected into the formation through one or more offset wells so as to cause the combustion zone to move through the stratum by inverse air drive.

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 initiating in situ combustion in a permeable carbonaceous stratum comprising, placing a gas permeable mass of a solid ignition fuel in a borehole within said stratum, said fuel comprising a normally solid polymer selected from the group consisting of polymers of 1-olefins, a transdiene polymer obtained from conjugated dienes of 4 and 5 carbon atoms, and admixtures thereof, and a normally liquid hydrocarbon, heating said fuel to ignition temperature, and passing a combustion supporting gas through said fuel mass so as to continue combustion of said ignited fuel, thereby heating and igniting a section of said stratum adjacent the burning fuel.
2. A process for initiating combustion in an ignition well within a carbonaceous stratum which comprises, introducing into said well a gas permeable combustible fuel pack comprising a mixture of particulate com-

bustible solids and particulate auto-ignitable solids being a normally solid polymer selected from the group consisting of polymers of 1-olefins, a trans-diene polymer of a conjugated diene of 4-5 carbon atoms, and mixtures thereof, and a normally liquid hydrocarbon,

igniting said fuel pack,

passing combustion supporting gas through the ignited fuel pack so as to continue combustion of said ignited pack, thereby heating and igniting a section of said stratum adjacent the burning fuel,

and venting gases from said well.

3. A process according to claim 2 wherein said fuel pack is ignited by passing a heated combustion-supporting gas at a temperature above about 750° F. through said pack.

4. A process for initiating in situ combustion in a permeable carbonaceous stratum comprising,

positioning a gas permeable mass of a fuel pack comprising a mixture of porous particulate combustible solids and particulate auto-ignitable ignitor solids selected from the group consisting of polymers of 1-olefins, a trans-diene polymer of a conjugated diene of 4-5 carbon atoms, and mixtures thereof, and a normally liquid hydrocarbon in a borehole in said stratum,

igniting said fuel pack in the lower portion thereof,

passing combustion supporting gas upwardly through said ignited fuel pack so as to drive same by direct drive to the top of the pack and effect combustion throughout said pack, thereby heating and igniting a section of said stratum adjacent the burning fuel pack,

and venting combustion gases from said borehole.

5. The process of claim 4 wherein tubing passes from ground level down to said fuel pack, further comprising passing said combustion-supporting gas at a temperature of at least about 750° F. downwardly through said tubing and introducing said gas into the lower portion of said fuel pack to ignite same,

continuing injection of combustion-supporting gas into the ignited area through said tubing to effect combustion throughout said pack,

and withdrawing effluent gases from the combustion through the annulus around said tubing.

6. The process of claim 5 further comprising injecting a combustion-supporting gas into said stratum through at least one offset well and passing said gas through said stratum into the burning fuel pack so as to propagate the combustion zone from said fuel pack into said stratum.

7. A process for initiating in situ combustion in a permeable carbonaceous stratum comprising,

positioning a gas permeable mass of solid fuel comprising a material selected from the group consisting of polymers of 1-olefins, a trans-diene polymer of a conjugated diene of 4-5 carbon atoms, and mixtures thereof, and a normally liquid hydrocarbon, provided with an axial gas passage therethrough, in a borehole within said stratum,

igniting said mass of fuel,

burning said mass of fuel by injecting combustion-supporting gas into said stratum at a locus spaced from said borehole so as to pass said gas into said borehole and into said mass of fuel, thereby heating and igniting the carbonaceous material in said stratum adjacent said borehole,

passing combustion gas from the burning fuel and said carbonaceous material into said axial passageway, upwardly therethrough, and out of said well.

8. A process for initiating in situ combustion in a permeable carbonaceous stratum comprising: placing a gas permeable mass of a solid ignition fuel in a borehole within said stratum, said fuel comprising normally solid polymer selected from the group consisting of polymers of 1-olefins, a trans-diene polymer obtained from conjugated dienes of 4 and 5 carbon atoms, and mixtures thereof, and a normally liquid hydrocarbon; passing a heated gas to said permeable mass to heat same to ignition temperature; and passing a combustion supporting gas through said fuel mass so as to continue combustion of said ignited fuel, thereby heating and igniting a section of said stratum adjacent the burning fuel.

9. The process of claim 8 wherein said fuel comprises 4-40 weight percent of said solid polymer and 60-96 weight percent of said liquid hydrocarbon.

10. A process for initiating combustion in an ignition well within a carbonaceous stratum which comprises, introducing into said well a gas permeable combustible fuel pack comprising a mixture of particulate combustible solids and particulate autoignitable solids comprising normally solid polymer selected from the group consisting of polymers of 1-olefins, a trans-diene polymer of a conjugated diene of 4-5 carbon atoms, and mixtures thereof, and a normally liquid hydrocarbon; igniting said fuel pack; passing combustion supporting gas thru the ignited fuel pack so as to continue combustion of said ignited fuel pack, thereby heating and igniting a section of said stratum adjacent the burning fuel, and venting gases from said well.

11. The process of claim 10 wherein said fuel pack has a composition comprising 4-40 weight percent of said solid polymer and 60-96 weight percent of said normally liquid hydrocarbon.

12. The process of claim 10 wherein ignition of said fuel pack is obtained by passing air at a temperature of about 800° F thereto.

13. A process for initiating combustion in an ignition well within a carbonaceous stratum which comprises, introducing into said well a gas permeable combustible fuel pack comprising a mixture of particulate charcoal and particulate autoignitable solids comprised of 4-40 weight percent polyethylene and 60-96 weight percent of a normally liquid hydrocarbon fuel boiling above about 300° F; igniting said fuel pack by introducing heated air at a temperature of about 800° F thereto; passing combustion supporting gas thru the ignited fuel pack so as to continue combustion of said ignited fuel pack, thereby heating and igniting a section of said stratum adjacent the burning fuel, and venting gases from said well.

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