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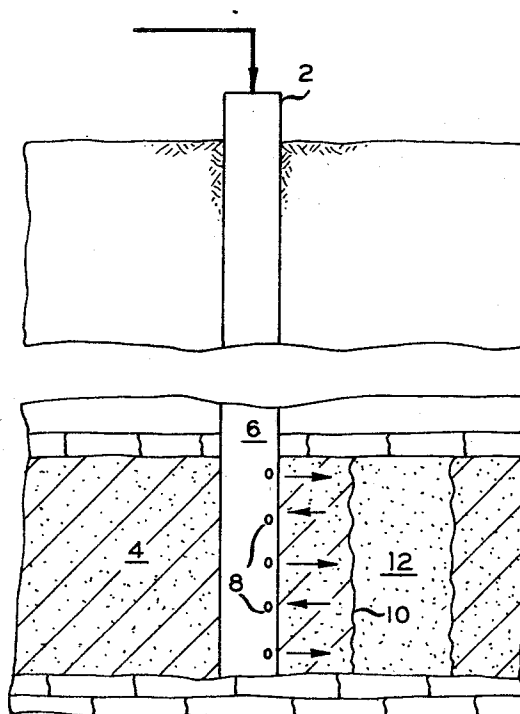
[54] **METHOD OF REMOVING PERMEABILITY BLOCKS**
5 Claims, 3 Drawing Figs.

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261, 260, 302

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ABSTRACT: A method for removing viscous oil and tar permeability blocks from a formation and preconditioning said formation in the vicinity of an injection well for subsequent injection of oxygen for direct drive in situ combustion.



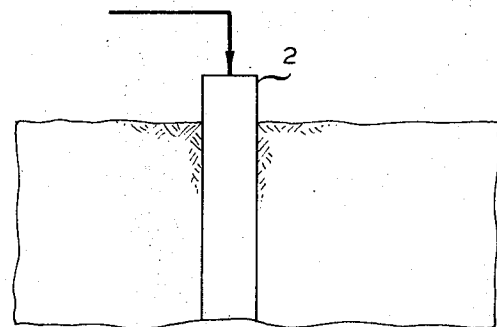
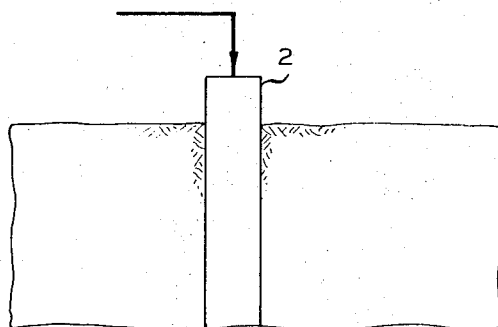
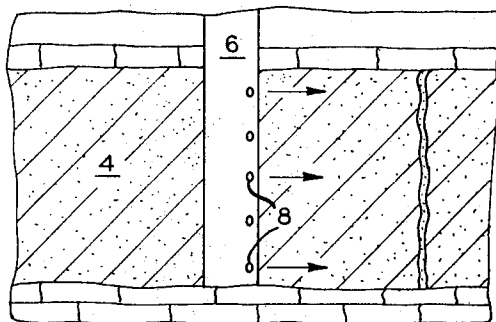
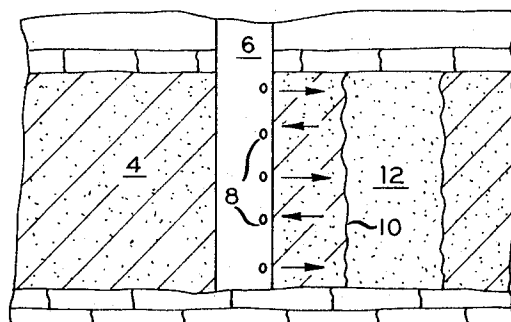


FIG. 1

FIG. 2

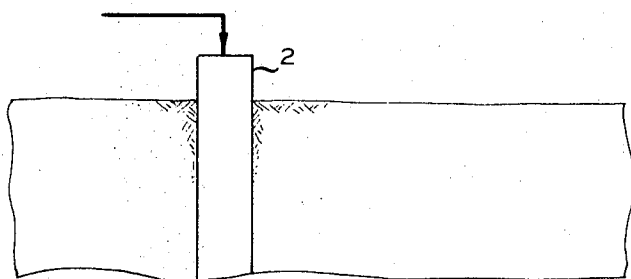
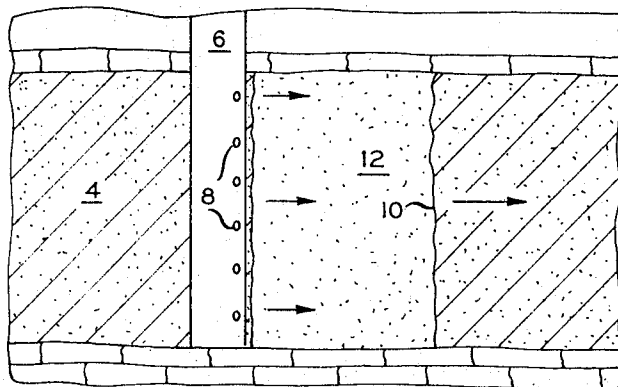


FIG. 3

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METHOD OF REMOVING PERMEABILITY BLOCKS

This invention relates to a method for removing viscous oil and tar permeability blocks within a subterranean hydrocarbon-containing formation. In another aspect, this invention relates to a method for treating a hydrocarbon-containing formation to remove viscous oil and tar permeability blocks and condition the formation for subsequent direct drive in situ combustion.

In formations which contain highly viscous oils or tars, it is often impossible to inject sufficient air into the formation to support direct drive in situ combustion. These viscous oils and tars form effective permeability blocks in the formation adjacent the injection well unless the hydrocarbon liquids are substantially completely removed from the formation for a radial extent from the well bore. After these viscous oil and tar permeability blocks have been removed, direct drive in situ combustion can be conducted through the formation. The oxygen for supporting the combustion zone then passes freely through the preconditioned zone surrounding the well and the combustion zone moving outwardly in response to oxidant injection thereafter sweeps the more remote portions of the formation and maintains permeable pathways for the oxygen to move from the preconditioned zone to the remote moving combustion zone.

It is therefore an object of this invention to remove the viscous oil and tar permeability blocks adjacent the well bore prior to producing the formation by direct drive in situ combustion methods. Another object of this invention is to remove substantially all of the hydrocarbon liquids and tars from an area encompassing the injection well bore to improve the passage of air therethrough for subsequent direct drive in situ combustion operations.

Other aspects, objects, and advantages of the present invention will become apparent from a study of the disclosure, the appended claims, and the drawing.

The drawings are diagrammatic views of the formation and injection equipment showing in FIG. 1 the establishment of a combustion zone, in FIG. 2 the movement of the combustion zone through the formation, and in FIG. 3 the initiation of direct drive in situ combustion operations.

Referring to FIG. 1, an injection well 2 penetrates a subterranean formation 4 that contains viscous oils and tars. The well 2 preferably has casing 6 set and cemented through the formation 4 with perforations 8 or openings formed through the casing and into the formation 4 in order to control the specific location at which oxidant is injected into the adjacent formation 4. An oxidant, preferably air, is injected downwardly through the injection well 2, through the perforations 8 of the casing 6, and outwardly through the formation 4 from the injection well 2 for initiation of combustion within the formation 4. In the method of this invention, the combustion zone 10 is initiated at a distance through the formation 4 from the injection well 2 in the range of not greater than 35 feet nor less than 15 feet. If the combustion zone 10 is formed greater than 35 feet from the well bore, the preconditioning operations will require an excessive amount of time and result in a waste of manpower, equipment, and materials relative to that needed to adequately precondition a zone extending a sufficient lateral distance from the injection well 2. If the combustion zone 10, on the other hand, is formed less than 15 feet from the well bore, the preconditioned zone 12 around the well bore 2 does not have a lateral extent sufficient to assure that permeability blocks, caused by viscous oils and tars, are not of a concentration such that oxidant injection is detrimentally restricted. The lateral distance from the injection well through the formation is therein utilized as the basis for measuring the preconditioned zone of this invention since the number of horizontal permeability pathways through a formation increases directly with the increase of lateral distance from that point. Since approximately three-fourths of the pressure losses of injection fluid occur generally within 20 feet of the well bore, it is preferred that the combustion zone 10 be initiated at a distance from the injection well 2 of about 20 feet. By so limiting the location of combustion zone initiation

to about 20 feet, optimum balance is achieved between forming a preconditioned zone of sufficient size and maintaining expenditures of labor, equipment, materials and time at the lowest possible level.

The distance from the injection well at which spontaneous ignition occurs is dependent upon the formation characteristics, pressure, temperature, and the characteristics of the in place fluids. Conventional laboratory analysis of core samples and fluid samples taken from the formation provides the information for determining the injection requirements of rate and oxygen content to spontaneously ignite the particular formation at a specific desired distance from the injection well 2. These laboratory analyses and calculations are easily and routinely made by one skilled in the art.

It is preferred that the distance from the injection well at which combustion is initiated is controlled by regulating the rate and temperature of oxidant injected or by regulating the rate of oxygen and water injected into the formation. It is also preferred that the oxygen injected for initiating combustion be in the form of air. Although other methods and materials are available to control the position of spontaneous combustion within the formation, oxygen concentration and fluid injection rate regulation are preferred so as to reduce the expense of the operation and utilize readily available materials.

Referring to FIG. 2, oxygen is thereafter injected into the formation at a rate to maintain movement of the combustion zone 10 through the formation 4 in a direction substantially toward only the injection well 2. This rate is dependent upon the characteristic of the specific reservoir and oxidant utilized but is a value that can be easily calculated by one skilled in the art. Injection of oxygen is continued at that preselected rate until the temperature within the injection well reaches about 600° F. That temperature reading is obtained from a thermocouple or other suitable device positioned within the casing 6 adjacent the formation 4 and indicates that the combustion zone 10 is a relatively short distance from the injection well 2. In order to prevent damage to the casing 6, the cement sheath around the casing 6, and other well equipment caused by heat of combustion, it is recommended that at the time the temperature reaches about 600° F. the rate of oxygen injection into the well 2 be reduced to maintain the temperature within the injection well below about 600° F. The oxygen is thereafter injected at this reduced rate until the temperature as recorded within the injection well falls below 600° F., thereby indicating substantially complete combustion and removal of the hydrocarbons adjacent the well bore 2. Thereafter the rate of oxygen injection into the well is increased to the rate desired for direct drive in situ combustion.

As seen in FIG. 3, at the time the temperature in the well 2 falls below about 400° F., the hydrocarbons immediately adjacent the casing 6 and encompassing cement sheath have been combusted and removed therefrom. The subsequent increase in oxygen injection rate moves oxygen through the preconditioned zone 12 into contact with the in place hydrocarbons and establishes a direct drive combustion zone moving through the formation from the injection well toward a remotely located producing well. The volume of oxygen injected into the well for controlling the temperature within the well can be regulated and controlled most easily by adding inert gas, such as carbon dioxide for example, to the air being injected. This addition of inert gas to the air permits injection compressors to operate at a normal rate while reducing the amount of oxygen delivered to the formation thereby simplifying the operation.

By moving a combustion zone 10 countercurrently through the formation 4 toward the well bore at a controlled rate, the viscous oil and tar forming permeability blocks are combusted or transported to other portions of the formation. The transportation of the viscous hydrocarbons from the preconditioned zone 12 is effected by reducing the viscosity of the hydrocarbons by increasing their temperature and the fingering of gases through the tar block. This removal of the viscous oils and tars produces a preconditioned zone substantially free

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of materials that prevent injection of oxidant into the formation and thereby conditions the formation for the passage of a volume of oxygen therethrough sufficient to maintain subsequent direct drive in situ combustion.

Other modifications and alterations of this invention will become apparent to those skilled in the art from the foregoing discussion and accompanying drawing, and it should be understood that this invention is not to be unduly limited thereto.

I claim:

1. A method for removing viscous oil and tar permeability blocks within a hydrocarbon-containing formation penetrated by an injection well comprising:

initiating combustion within the formation at a distance within the range of not greater than 35 feet and not less than 15 feet from the well bore of the injection well;

injecting oxygen into the formation at a rate to maintain movement of the combustion zone substantially toward only the injection well;

decreasing the rate of oxygen injection into the well to maintain the temperature within the injection well below about 600° F. while moving the combustion zone through

the formation toward the injection well;

continuing oxygen injection into the well and maintaining the temperature within the well below about 600° F. until the temperature within the injection well falls below 400° F.

2. A method, as set forth in claim 1, wherein combustion is initiated within the formation at a distance of about 20 feet from the injection well.

3. A method, as set forth in claim 1, wherein the oxygen is injected into the formation in the form of air and the amount of oxygen injected is controlled by adding inert gas to the air.

4. A method, as set forth in claim 1, wherein the distance from the injection well at which combustion is initiated is controlled by controlling the rate and concentration of oxygen injected downwardly through the well and into the formation.

5. A method, as set forth in claim 1, wherein the distance from the injection well at which combustion is initiated is controlled by injecting water and oxygen at a controlled rate downwardly through the well and into the formation.

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