

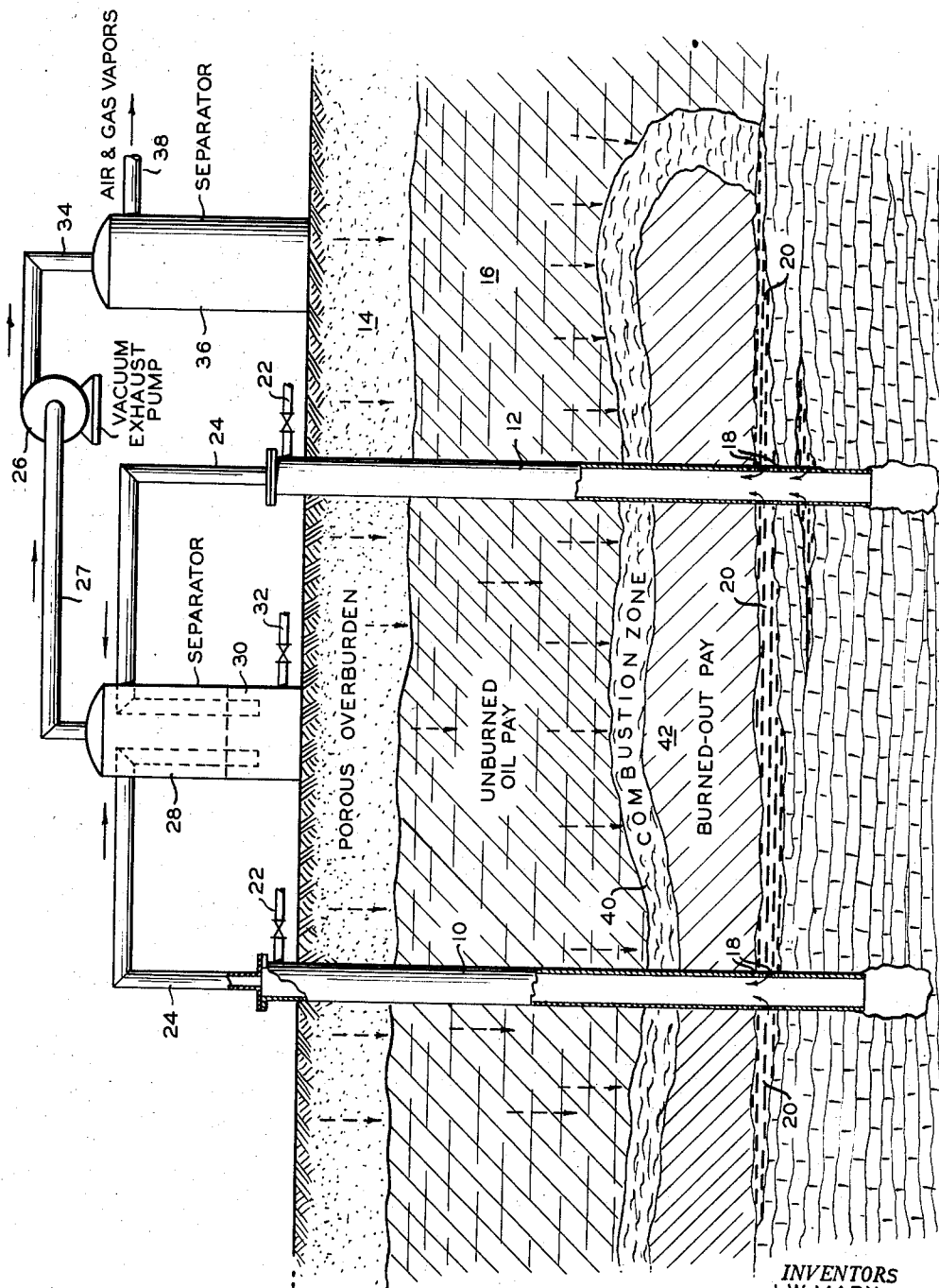
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J. W. MARX ET AL

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OIL RECOVERY BY IN SITU-COMBUSTION

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INVENTORS
J. W. MARX
M. R. TEK

BY *Hudson & Young*
ATTORNEYS

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OIL RECOVERY BY IN SITU-COMBUSTION

John W. Marx and Mehmet R. Tek, Bartlesville, Okla.,
assignors to Phillips Petroleum Company, a corpora-
tion of Delaware

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5 Claims. (Cl. 166—11)

This invention relates to a process and arrangement of apparatus for recovering oil by in situ-combustion from an underground oil bearing formation.

The recovery of oil from oil-bearing formations by in situ-combustion has recently come into use. The method comprises starting combustion by any suitable means in the formation around an injection well and injecting air into the formation thru the injection well so as to drive the combustion zone away from the well and recover combustion products and produced oil from a remote well. In this technique of oil recovery considerable pressure is required to force air through the formation, including the combustion front and, particularly, the unburned area to the output well. The co-pending application of John Marx, Serial No. 526,388, entitled "Oil Recovery Process," discloses an in situ-combustion oil recovery technique which utilizes inverse air injection to propagate a combustion front from an area around a well to surrounding wells whereby the pressure required to force the air from the input well to the output well is substantially less than is required by direct air injection operation.

We have devised a method of operation and arrangement of apparatus for recovering hydrocarbons from an oil bearing formation situated relatively close to the surface of the ground and covered by a porous overburden which utilizes atmospheric pressure on the surface of the ground as the means of supplying air to the combustion front and avoids the difficulties of direct air injection.

Accordingly, it is an object of the invention to provide a process and arrangement of apparatus for producing hydrocarbons from an oil-bearing formation by in situ-combustion for use in formations relatively close to the surface which are covered by a porous overburden. Another object is to provide a process and arrangement of apparatus for recovering hydrocarbons from an oil-bearing formation utilizing inverse air flow to advance the combustion front at normal atmospheric pressure. A further object is to provide a method of moving a combustion front in an in situ-combustion oil recovery process upwardly and countercurrently to the flow of air to the front. It is also an object of the invention to provide a process for the recovery of oil from an oil bearing formation by in situ combustion which provides gravity flow of the produced liquids through the burned out section of the formation. Other objects of the invention will become apparent from a consideration of the accompanying disclosure.

In accordance with the invention, an in situ-combustion front is established in an extended horizontal area along a lower level of the formation and air from the atmosphere at the ground surface is forced through the porous overburden and through the upper section of the formation to the combustion front so as to advance the front upwardly and countercurrently to the flow of air. This is done by evacuating gas from a well penetrating the formation in the combustion area so as to create a pres-

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sure drop between the atmosphere at the ground level and the openings in the well casing at the level of the formation at which the combustion is initiated. In this manner inverse air flow is induced in the formation so as to cause the combustion front to rise through the formation as air is fed to it and the liquid and gaseous hydrocarbons driven from the combustion area pass through the burned out section of the formation and to the well in which the vacuum or reduced pressure is applied. The process is facilitated by fracturing the formation at a lower level therein preferably at the bottom thereof around one or more wells arranged in any suitable pattern. The process may also be effected through a single well.

A more complete understanding of the invention may be had by reference to the accompanying schematic drawing which is a vertical section through an oil bearing formation showing one arrangement of apparatus for effecting the process of the invention. Referring to the drawing, well casings 10 and 12 penetrate porous overburden 14 and oil bearing formation 16 to a lower level thereof. Perforations 18 in the casings are positioned at a lower level of the formation where combustion is initiated. Fractures 20 are formed by conventional means such as hydraulic fracturing through openings 18 in order to facilitate the establishment of combustion in a substantial horizontal area of the formation.

After fracturing of the formation at the desired level combustion of the hydrocarbon in and adjacent the fractures is initiated by any suitable means such as by injection of air at a combustion supporting temperature through conduits 22 and casings 10 and 12. Combustion in the fractures may also be induced or initiated by an electric heating unit together with a supply of air, or by a combustion squib. It is also feasible to introduce an electrically conducting propping agent to the fractures during fracturing and quickly establish a combustion zone of the pancake type by use of an electric current and combustion-supporting gas. After a combustion front is established and a substantial area is heated up and burning, flow of air through conduits 22 is cut off and a vacuum is applied through lines 24 by means of vacuum exhaust pump 26 connected with lines 24 through line 27 and preferably through a separator 28 in which liquids 30 are released and drawn off as desired through line 32. Effluent gas from exhaust pump 26 is passed via line 34 to separator means 36 which may include a condensing means for recovering condensable hydrocarbon from the effluent gases, as well as means for separating condensed water and hydrocarbons. The effluent or condensed gases are vented or passed to other disposal through line 38.

As a vacuum is applied to the formation through the casings and openings 18 therein, flow of air is induced by the resulting pressure drop through the porous overburden 14 and the unburned oil-bearing formation above combustion zone or front 40 so that the combustion front advances upwardly through the formation countercurrently to the flow of air. Liquid and gaseous hydrocarbons existing and formed in the combustion zone pass through the partially burned out area 42 and flow to openings 18 in casings 10 and 12 from which they are recovered through lines 24 and separators 28 and 36. Because of the higher permeability of burned out section 42, the flow of liquid and gaseous hydrocarbons therethrough is greatly facilitated and gravity flow of liquid hydrocarbons thru the burned out area is taken advantage of. With this type of recovery, considerable cracking of hydrocarbon is effected in the hot combustion zone of the formation, which facilitates recovery and upgrading of the produced oil.

The process of the invention is applicable to primary,

secondary, or tertiary recovery programs in shallow formations.

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.

We claim:

1. A process for recovering hydrocarbons from an underground formation containing the same covered by an air-pervious overburden extending to the ground surface, which comprises initiating combustion of hydrocarbons in a lower section of said formation to produce a burned out zone therein; reducing the pressure in said burned out zone so as to cause air to flow thru said porous overburden directly from the atmosphere over a large area of the exposed surface of same and thru the upper section of said formation and advance the combustion zone upwardly inversely to the flow of air; and recovering hydrocarbons driven from said formation.

2. The process of claim 1 wherein said formation is fractured at said lower level between a pair of boreholes, in situ-combustion of hydrocarbons is established to at least partially burn out a substantial zone adjacent the fractures, and a vacuum is applied to said zone thru said boreholes.

3. The process of claim 2 wherein hydrocarbons are produced thru said boreholes.

4. A process for producing hydrocarbons from an underground formation containing the same covered by an air-pervious overburden; which comprises establishing an in situ-combustion front along a lower level of said formation; forcing air downwardly thereto thru an extensive horizontal area of said air-pervious overburden so as to advance said combustion front over an extensive area of said formation upwardly inversely to air flow; and recovering hydrocarbons driven out of said formation by said combustion.

5. The process of claim 4 wherein said formation is penetrated by at least one well; said formation is fractured along said lower level prior to initiation of combustion therein; and vacuum is applied thru said well and fracture to said formation.

References Cited in the file of this patent

UNITED STATES PATENTS

2,112,845	Howell	Apr. 5, 1938
2,584,605	Merriam et al.	Feb. 5, 1952
2,630,307	Martin	Mar. 3, 1953