

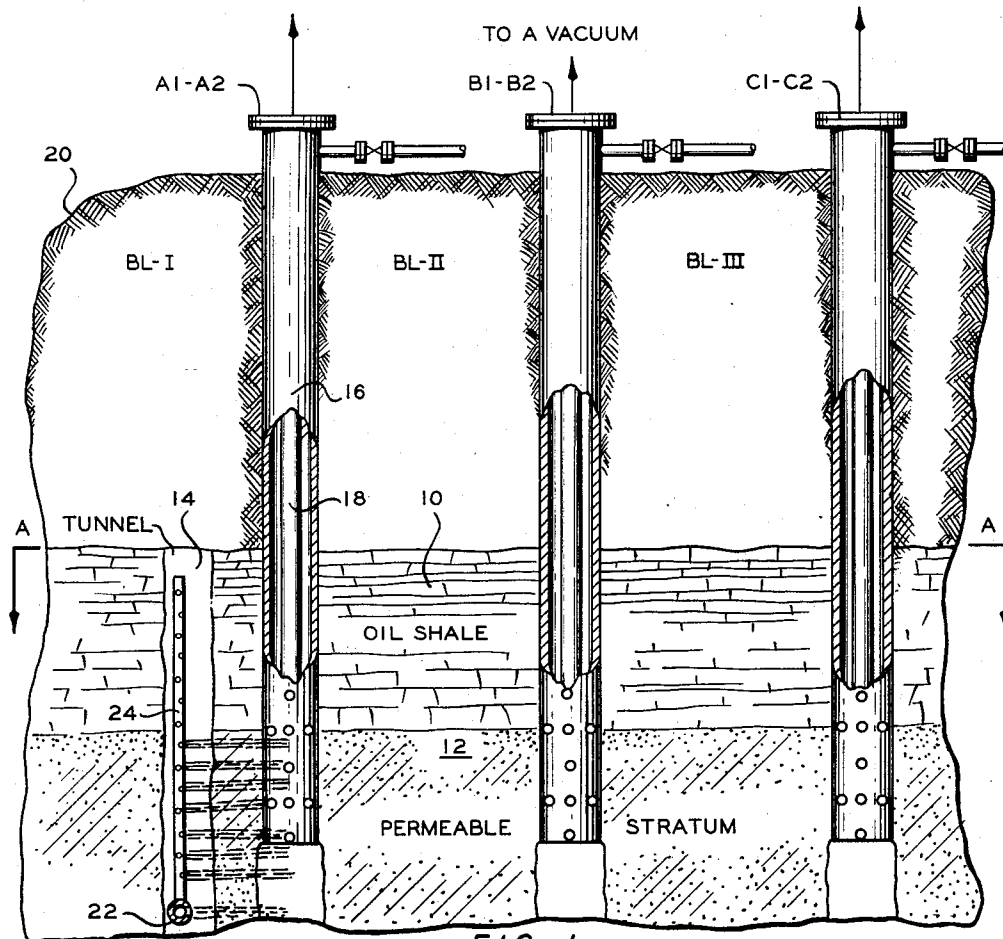
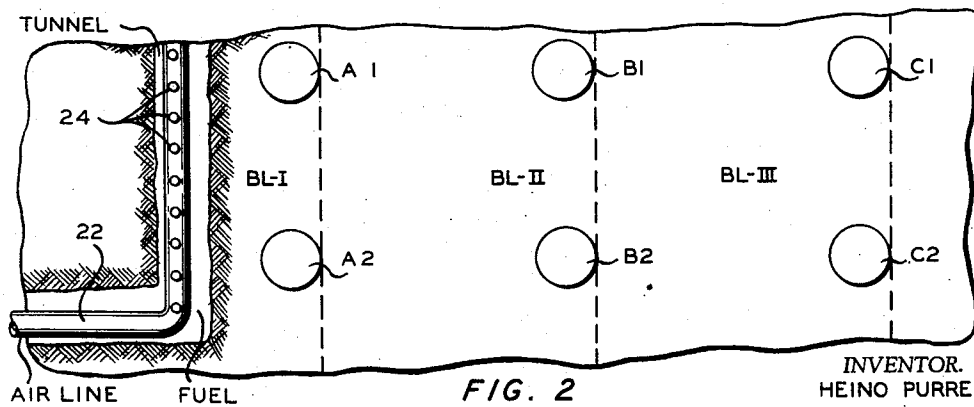
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IN SITU RETORTING OF OIL SHALE

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IN SITU RETORTING OF OIL SHALE

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This invention relates to a process and arrangement of apparatus for in situ recovery or retorting of hydrocarbon from oil shale.

Large deposits of oil in the form of oil shale are found in various sections of the United States and, particularly, in Colorado and surrounding states. Various methods of recovery of oil from these shale deposits have been proposed and the principal difficulty with these methods is the high cost which renders the recovered oil too expensive to compete with petroleum crudes recovered by more conventional methods. The in situ retorting of oil shale to recover the oil contained therein is made difficult because of the nonpermeable nature of the oil shale and the difficulty of applying heat thereto without extensive mining or drilling operations. The mining and removal of the oil shale for retorting of the shale in furnaces outside the formation is commercially uneconomical in most cases.

Accordingly, it is an object of the invention to provide a process and arrangement of apparatus for in situ retorting and recovery of hydrocarbon from an oil shale stratum lying adjacent a permeable stratum. Another object is to provide a process and an arrangement of apparatus for in situ retorting of oil shale which utilizes crushed oil shale as the fuel for the process. Other objects of the invention will become apparent from a consideration of the accompanying disclosure.

The invention comprises forming a tunnel by mining, boring, and/or other means, in an extensive section of an oil shale stratum and adjacent a permeable stratum, parallel with these strata, drilling one or more boreholes thru the strata spaced from the tunnel a short distance which permits flow of gas from the tunnel to the borehole, and burning sufficient fuel in the tunnel to heat up the oil shale lying adjacent the permeable stratum so as to fluidize and drive the oil in liquid and/or gaseous form to the borehole from which it is recovered in conventional manner. In a preferred embodiment of the invention, the oil shale removed in forming the tunnel is then stacked in the tunnel in a permeable or perforate mass and is burned with air supplied from the mouth of the tunnel connecting with the earth's surface. The air, in one embodiment of the invention, is supplied by means of a conduit system connected with a forced air system for forcing air thru the mass of fuel. In order to assist in forcing the hot combustion gas resulting from the burning step thru the permeable stratum to the borehole a vacuum is applied to the borehole or to the conduit extending into the borehole. It is also feasible to utilize vacuum on the production borehole system as the sole force for driving air thru the fuel and combustion gas thru the permeable stratum.

The invention is particularly applicable to an oil shale formation overlying or underlying a permeable stratum which forms an outcropping in the side of a hill, bluff, or mountain. In such a structure, an L-shaped tunnel is readily formed by conventional mining operation so that the long section of the L runs parallel with the out-

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cropped line. A series of boreholes are drilled thru the formation from the earth's surface along a line generally parallel with the tunnel to permit retorting of the oil shale thru the series of conduits. Other series of conduits or boreholes are drilled thru the strata along an upright plane more remote from the tunnel than the first series of boreholes; and succeeding series of boreholes are made in the strata so as to permit retorting of the shale in blocks successively and progressively more remote from the tunnel.

A more complete understanding of the invention may be had by reference to the accompanying drawing of which Figure 1 is an elevation in partial cross section of a formation and arrangement of apparatus therein for retorting oil shale in accordance with the invention, and Figure 2 is a horizontal section taken on a line A—A of Figure 1.

Referring to Figure 1, an oil shale stratum 10 overlays a permeable stratum 12, and these strata are penetrated by three series of boreholes A-1, A-2, etc., B-1, B-2, etc., and C-1, C-2, etc., which are spaced progressively more remotely from tunnel 14. The boreholes are provided with conventional casing 16 and tubing 18 for recovery of produced oil in liquid and vapor form. The casing is preferably perforated in the section coinciding with the oil shale and permeable strata.

The upright outline of the hill or cliff is shown at 20. The tunnel is formed by penetrating the oil shale and permeable strata from the outcropping surface until a suitable penetration has been made substantially horizontally and away from the upright or oblique surface of the outcropping. When suitable penetration has been made, an L-turn is made and the long section of the tunnel is formed parallel with the formation and with the outcropping line.

The L-shape of the tunnel is shown in Figure 2, along with illustrative spacing and arrangement of the A, B, and C series of boreholes. The arrangement shown divides the formation into blocks I, II, and III for production or retorting in sequence. Fuel comprising the particulate shale removed from the formation during formation of the tunnel or from other suitable source is stacked into the tunnel to substantially fill the same so that, upon burning of this fuel, heat is provided for retorting the oil shale. Air can be admitted to the fuel in the tunnel for supporting combustion thereof thru the mouth of the tunnel without special conduits for this purpose, the air passing thru the interstices among the particulate material. However, it is more efficient to position a conduit system in the tunnel for the distribution of air to various sections of the fuel.

Such a conduit system for distribution of air comprises a header or main feed line 22 and a plurality of branch conduits 24 which are perforate or provided with nozzles (not shown). The air distribution conduit system is, of course, disposed in the tunnel before packing the same with fuel. It is advantageous to dispose or position squibs or other starting devices for initiating combustion of the fuel at several spaced-apart locations in the mass of fuel with wires connected to the same with a current source outside of the tunnel for setting off the squibs or other starting devices.

It is also feasible to introduce combustion air to various sections of the tunnel and fuel mass by means of drilled holes from the face of the outcropping into the tunnel at spaced-apart locations along the tunnel and outcropping line. Conduits may be provided in these air boreholes and means for regulating the flow of air thru the conduits may also be provided.

When the oil shale in block I has been substantially completely retorted and carbonized, with the produced hydrocarbon being withdrawn thru boreholes A-1, A-2,

etc., by means of air pressure thru the tunnel and/or vacuum applied to the casing and/or tubing in the borehole or by other suitable means, the flow thru these boreholes is cut off and vacuum is applied to boreholes B-1, B-2, etc., so that oil is produced from the oil shale in block II in similar manner to retorting of the oil shale in block I.

As the shale in block I is retorted by heat from the burning of fuel in the tunnel and flow of hot gases thru the permeable stratum along the oil shale layer, block I gradually becomes carbonized and permeable so that a combustion front initiated therein by the burning fuel moves thru the carbonized oil shale stratum, thereby producing ample heat to retort and carbonize the shale in block II. When the combustion front passing thru block I reaches wells A-1, A-2, etc., the carbonization of block II may be considered as completed and it is then feasible to supply combustion air for propagation of the combustion front thru block II directly thru wells A-1, A-2, etc., and in order to utilize the heat produced by burning the residual carbon in block II for retorting block III wells B-1, B-2, etc., are closed and the hot combustion gases and gaseous hydrocarbons are withdrawn thru wells C-1, C-2, etc. In this manner during the burning of residual carbon in block II, the oil shale in block III is retorted and gradually carbonized so that by the time the combustion front reaches wells B-1, B-2, etc., wells C-1, C-2, etc., are closed and combustion air is admitted thru wells B-1, B-2, etc., and produced hydrocarbon and combustion gas is recovered thru the next set of wells in the series, which are not shown.

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 recovery of hydrocarbons from an impermeable underground stratum containing same lying adjacent a permeable stratum which comprises forming a tunnel in these strata parallel therewith and at the same level extending along a substantial section of the strata; forming at least one borehole thru said strata spaced from said tunnel; heating and producing hydrocarbons from said impermeable stratum by introducing hot gas to said tunnel and forcing same thru the pores in said permeable stratum to said borehole thereby heating the adjacent impervious layer so as to drive fluidized hydrocarbon therefrom; and recovering hydrocarbon thru said borehole.

2. The process of claim 1 wherein said strata are outcropping and said tunnel is formed in a generally L-shape, extending inwardly from the outcropping edge and then along the strata generally parallel with the outcrop line.

3. The process of claim 2 wherein a vacuum is applied to said borehole to force gas thru said permeable stratum.

4. The process of claim 1 wherein said hot gas is formed in situ by burning fuel in said tunnel.

5. The process of claim 4 wherein said fuel comprises particulate shale produced in forming said tunnel.

6. A process for recovery of hydrocarbons from an impermeable hydrocarbon bearing shale stratum lying adjacent a permeable stratum which comprises forming a tunnel in these strata parallel therewith and at the same level, extending along a substantial section of the strata; forming a first series of boreholes in said strata spaced a selected distance from said tunnel; forming a second

series of boreholes in said strata spaced farther from said tunnel than said first series; burning fuel in said tunnel and forcing resulting hot combustion gas thru said permeable stratum to said first series of boreholes, thereby heating said shale so as to fluidize and drive hydrocarbons therefrom and carbonize residual hydrocarbon therein; after the area of said shale intermediate said tunnel and said first series of boreholes has been substantially produced and carbonized, cutting off flow of hot fluids thru said first series and forcing same thru the area of said strata intermediate said first and second series of boreholes to said second series of boreholes; and recovering fluid hydrocarbons from both series of boreholes.

7. The process of claim 6 wherein said fuel comprises particulate shale produced in forming said tunnel and stacked therein in an air permeable mass.

8. The process of claim 7 wherein the mouth of said tunnel is sealed and air is distributed to said mass thru the conduit means extending into and along said tunnel from a source outside thereof.

9. The process of claim 6 including initiating a combustion front in the carbonized shale residue adjacent said tunnel and causing same to pass thru the shale stratum to the first series of wells; during burning of the carbonized residue, maintaining the first series of wells closed and withdrawing produced and combustion gases from said second series of boreholes, thereby retorting and carbonizing the hydrocarbon in the shale intermediate the first and second series of boreholes.

10. An arrangement of apparatus for producing hydrocarbons from an oil shale stratum lying in a formation adjacent a permeable stratum which comprises a tunnel in these strata parallel therewith and at the same level; means for introducing hot gas to said tunnel; and a series of conduits extending into said strata from above ground for withdrawing fluids therefrom, said conduits being spaced laterally from said tunnel a distance permitting gas flow from said tunnel thru said stratum to said conduits.

11. The arrangement of claim 10 wherein said conduits are positioned substantially equidistant from said tunnel and including a second series of similar conduits positioned more remotely from said tunnel and substantially equidistant from said tunnel.

12. The arrangement of claim 10 wherein said tunnel is packed with a permeable mass of fuel.

13. The arrangement of claim 12 including conduit means extending into said mass of fuel from a source of air outside of said tunnel to distribute air to said fuel at spaced apart points therein.

14. The arrangement of claim 13 wherein said conduit means comprise a header running lengthwise of said tunnel and perforate branch conduits extending into said mass of fuel from said header at points along same.

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