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Janssen et al.

[11] **3,917,344**

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[54] **INSITU RETORTING SYSTEM**

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[52] **U.S. Cl.** **299/2**; 166/266

[51] **Int. Cl.²** **E21C 41/10**

[58] **Field of Search** 299/2, 4, 5; 166/265, 266

[56] **References Cited**

UNITED STATES PATENTS

1,634,236	6/1927	Ranney	299/2
2,630,306	3/1953	Evans	299/2
2,970,826	2/1961	Woodruff	166/265
3,661,423	5/1972	Garret	299/2

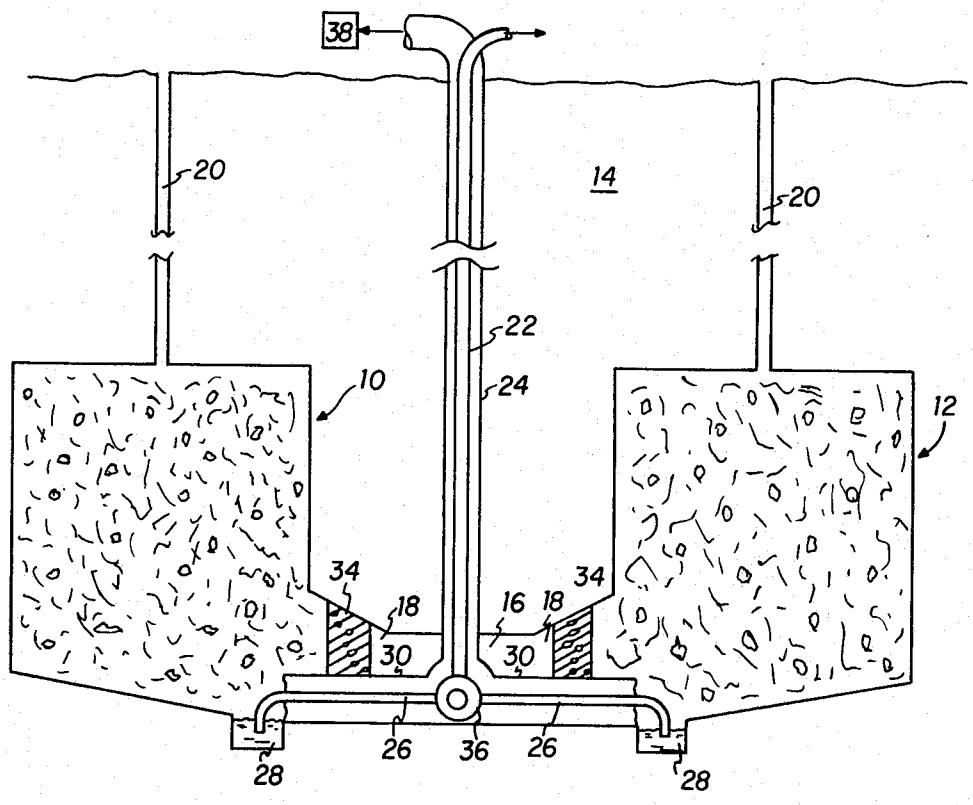
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[57] **ABSTRACT**

A system for in situ retorting and recovery of carbonaceous values from underground formations of oil shale. A plurality of parallel access entries communicating with the surface extend horizontally at a level beneath the formation. Upright retort chambers are arranged at spaced intervals on opposite sides of each access entry. The bottom of each chamber is interconnected with one such access entry by means of a sealed transverse tunnel. The retort chambers are ignited from the top and the carbonaceous values released from the shale by a downwardly progressing heat front are collected at the bottom. Oil recovery conduits extend from the surface through vertically directed bore holes opening into the access entry, each such conduit branching at that point to interconnect with opposite pairs of retort chambers through the sealed tunnels. Further conduit means are provided for scavenging gaseous retort products through an annular space surrounding each of the oil recovery conduits so as to apply constant heat to the shale oil while it is being conducted to the surface. Means are also provided for insuring that a positive pressure is maintained in the access entries with respect to the bottom of the retort chambers.

8 Claims, 2 Drawing Figures



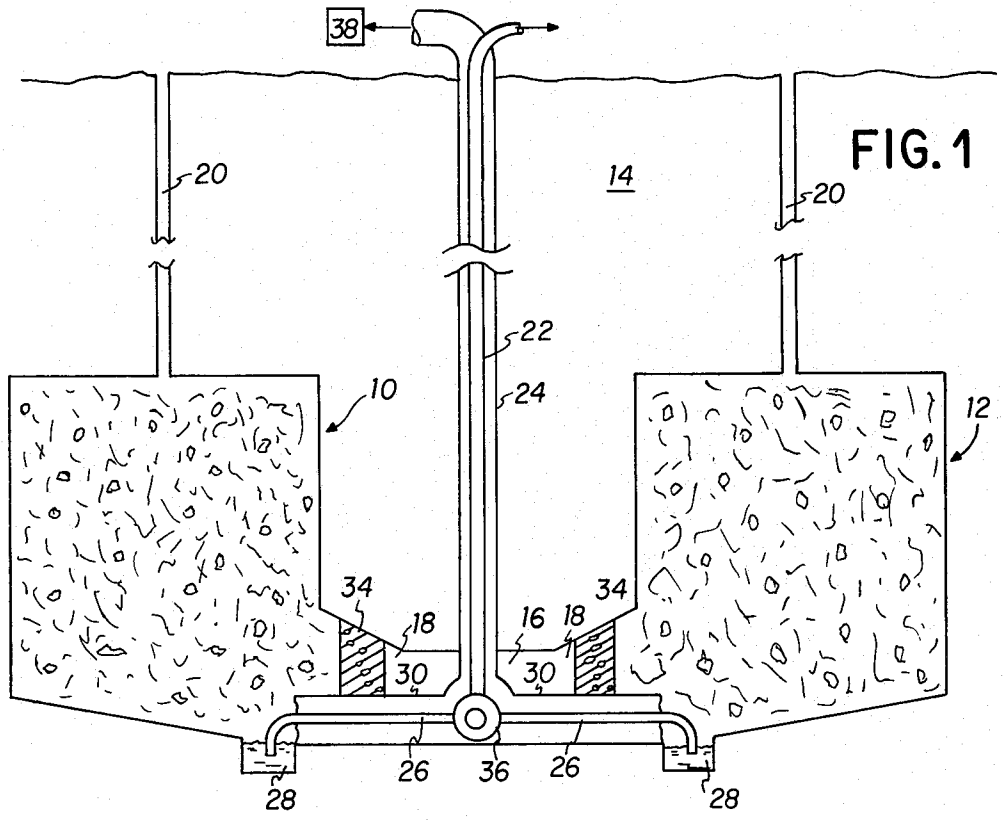

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FIG. 1

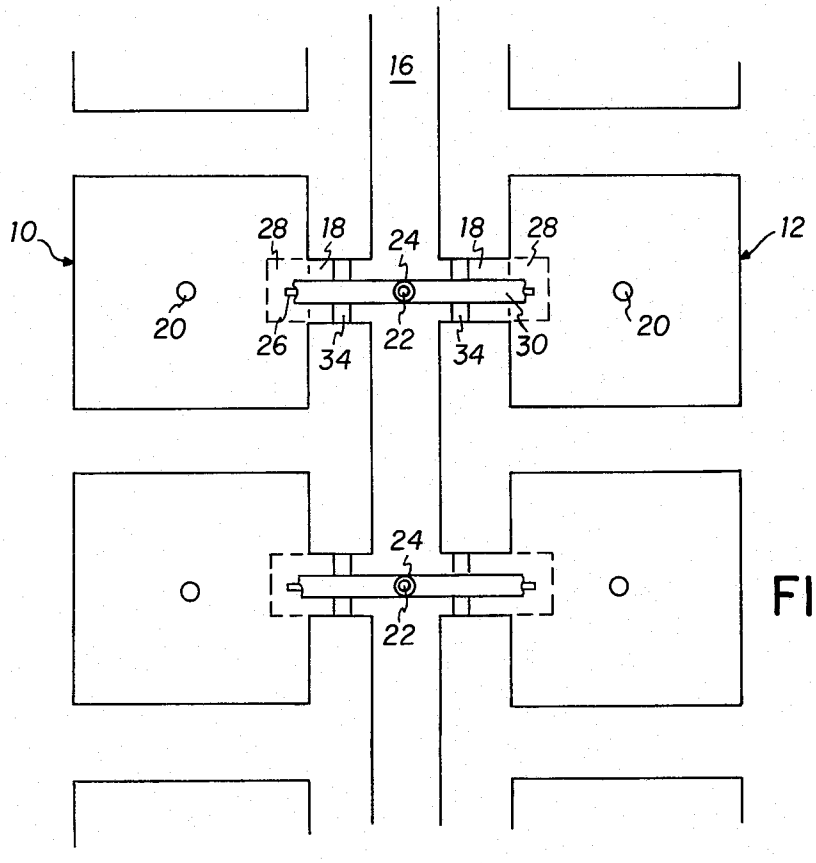

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FIG. 2

SITU RETORTING SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention.

This invention relates generally to the in situ retorting of underground ore deposits and more particularly to a system for retorting multiple adjacent chambers or zones within a deposit of carbonaceous material.

2. Description of the Prior Art.

In the art of in situ retorting it is conventional to create an underground zone of requisite permeability and porosity and initiate therein a vertically moving heat front. As, for example, in U.S. Pat. No. 3,001,776, the action of such a heat front pyrolyzes kerogen in a deposit of oil shale causing the evolved liquid and associated vapor to descend to the bottom of the retort for collection. The resultant carbonaceous values may be thereafter conducted to the surface for recovery and subsequent treatment. In this prior art method, liquids and vapors are combined more or less indiscriminately and fed into a common conduit leading to a common sump communicating with the surface. The liquid values will, therefore, experience a considerable amount of cooling and thickening after leaving the individual retorts, which renders pumping less efficient.

Another prior art process for in situ retorting and recovery of carbonaceous values is discussed in U.S. Pat. No. 3,661,423. This patent discloses a permeable retort zone wherein released carbonaceous values are collected at the floor for pumping to the surface. Separate conduits for liquid and vaporized products are interconnected between the surface and the base of the retort. No indication is given, however, of the manner in which the liquid and vaporized values are to be separately collected at the floor of the retort.

Neither of the patents cited covers the incorporation of multiple retort chambers within a practical large scale underground operation of the type which contemplates the frequent or continuous presence therein of personnel in connection with progressive chamber development and retorting. AS a consequence, the prior art of in situ retort systems seems ill-suited to the provision of adequate ventilation regimes, despite the fact that in situ retorting of oil shale releases highly noxious gases from which operating personnel must be carefully protected.

SUMMARY OF THE INVENTION

The present invention is directed toward an apparatus and method for the in situ retorting of underground carbonaceous formations and for the recovery therefrom of liquid and vaporized products. At least one bore hole is drilled in a substantially vertically downward direction from the earth's surface so that it opens into an access entry extending approximately horizontally adjacent the base of a permeable retort chamber or zone within such a formation. The base of the chamber is interconnected with the access entry through a transverse tunnel provided with a bulkhead to prevent the passage therethrough of retort gases. An oil recovery conduit extends from the surface through the bore hole and the transverse tunnel into communication with a liquid gathering sump at the floor of the retort chamber. A larger gas collecting conduit surrounding the oil recovery conduit in spaced relation has its lower end opening generally into the base of the chamber. Upon retorting of the chamber by known techniques, as by means of a downwardly directed heat front, liquid values are released and collect in the sump. Means are provided for pumping the liquid values from the sump to the surface through the smaller oil recovery conduit. Vacuum pump means at the surface draw hot retort gases into the annulus between the oil recovery and gas collecting conduits and thence to the surface. The result is that liquid values are subjected to constant heating throughout passage to the surface from the retort chamber. In addition, a degree of vacuum is induced at the bottom of the chamber so that there is an effective positive pressure within the access entry to protect working personnel from leakage through the tunnel of noxious gases.

In another aspect the invention comprises a system of adjacent underground permeable retort chambers having their bottom ends respectively interconnected with at least one horizontally extending access entry by means of a series of sealed transverse tunnels. A plurality of spaced apart bore holes extend vertically downwardly from the surface so that they communicate with the access entry. An oil recovery conduit extends entirely through each such bore hole from the surface into the access entry, at which point each such conduit branches and communicates through the transverse tunnels with separate liquid gathering sumps at the bottom of two or more of the retort zones respectively. A pump for driving shale oil to the surface after collecting in the sumps may be situated within the access entry at the point of juncture between each such group of branching oil recovery pipes and their associated oil recovery conduits. Each of these branch pipes is surrounded concentrically by a substantially equivalent length of gas collecting pipe which interconnects each bore hole with the bottom of one of its associated retort chambers. In this manner, retort gases are conveyed simultaneously from a plurality of retort chambers into a single bore hole in the annular space surrounding a single oil recovery conduit and provide a continuous source of heat therefor.

It is, therefore, a general object of this invention to provide an apparatus and method for in situ retorting and recovery of liquid and vaporized values from an underground carbonaceous formation with greater efficiency.

It is another object of this invention to provide a method for in situ retorting and recovery of carbonaceous values from an underground formation of oil shale wherein operating personnel are protected from the presence of noxious gases.

It is yet another object of this invention to provide a method and apparatus for in situ retorting and recovery of carbonaceous values from an underground formation of oil shale wherein means are provided for continuously heating the shale oil during passage from the underground retort to the surface.

Still another object of this invention is to provide an apparatus and method for recovering carbonaceous values from an underground formation of oil shale which is particularly adapted to progressive mining and in situ retorting on a large scale.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view of apparatus to facilitate the in situ retorting and recovery of carbonaceous values from an underground formation of oil shale.

FIG. 2 is a plan view of a system in accordance with this invention for the in situ retorting and recovery of

carbonaceous values from an underground formation of oil shale.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1, there is illustrated a pair of retort chambers 10 and 12 containing ore in a permeable, porous state, which has been formed within an underground carbonaceous formation 14, such as, for example, oil shale. The chambers 10 and 12 may be formed by various means well-known to the art such as by explosive fragmentation and expansion. A preferred method for accomplishing such expansion is described in copending application Ser. No. 499,697.

With additional reference to FIG. 2, the chambers 10 and 12 are illustrative of any pair of such chambers interconnected with a horizontally extending access entry 16 on opposite sides thereof by means of individual transverse tunnels 18. The access entry 16 may communicate at one or both its ends with the surface either directly through a vertical shaft or through intermediate horizontal drifts (not shown).

Preparatory to retorting of the chambers 10 and 12 at least one downwardly directed air hole 20 is drilled into the top of each such chamber from the surface of the earth or from an upper mining level. A source of air and fuel may then be introduced through each of the air holes 20 sufficient to establish combustion within the permeable mass in the chamber 10 or 12.

A pair of concentric conduits consisting of an inner oil recovery conduit 22 and an outer gas recovery conduit 24, encased within a suitable bore hole, lead vertically downward from the surface into communication with the access entry 16 between the chambers 10 and 12. At this point a pair of branching oil pipes 26 interconnect the bottom of each oil recovery conduit 22 with an oil sump 28 situated in the sloping floor of each of the chambers 10 and 12 adjacent the respective tunnels 18. Preferably the floor of each chamber 10 and 12 is sloped with an approximately ten percent grade downwardly toward the sump 28. In similar fashion a pair of larger open-ended, branching gas collecting pipes 30 surround the branch oil pipes 26 and interconnect the base of the gas conduit 24 with the bottom of the chambers 10 and 12 respectively through the tunnels 18.

In order to prevent the passage of noxious gases between the interior of chambers 10 and 12 and the access entry 16, suitable means are provided for sealing the tunnels 18, such as bulkheads 34. Each of the bulkheads 34 may be, for example, several feet in thickness and constructed of timber and sand or concrete. Typical construction may include a board frame on the side facing the chambers 10 or 12 with a steel reinforcement on the opposite side facing the access entry 16, the latter to be removed after the chamber 10 or 12 is completely produced and abandoned. Suitable openings are provided in the bulkheads 34 to accommodate passage therethrough of the respective gas collecting pipes 30 in a substantially air-tight fashion.

In operation, chambers 10 and 12 may be retorted in any known manner as, for example, by means of a downwardly directed heat front. As the kerogen in the ore in these chambers is pyrolyzed and releases its carbonaceous values, liquid oil flows to the sumps 28. An oil pump 36 may be positioned within the access entry 16 at the juncture of the base of each oil recovery conduit 22 and its associated branch oil pipes 26 so that these liquids are driven to the surface through the conduit 22. At the same time, a vacuum pump 38 at the surface may be operably interconnected with each of the gas collecting conduits 24 so as to effectively remove gas evolved in the retort operation from the base of each of the chambers 10 or 12. These gases flow into and occupy the annular space between the branch gas collecting pipes 30 and the branch oil pipes 26. Thereafter such gases fill the corresponding space between the oil recovery conduit 22 and the gas recovery conduit 24. In this manner, heat is applied to the liquids evolved from the retort process from the time they reach the sumps 28 until recovery at the surface.

At the surface the gases from the gas collecting conduit 24 may be applied at the top of other retort chambers adjacent to chambers 10 and 12 for the purpose of preheating or, if sufficiently hot, for directly retorting such adjacent chambers.

In a complete large scale shale oil recovery operation, it may be desirable to develop and retort, in progressive fashion, a plurality of adjacent chambers such as chambers 10 and 12 in accordance with this invention. A practical and feasible mining layout well adapted for this purpose is described in more detail in copending application Ser. No. 499,696. Under these circumstances it may be desirable and economical within the scope of this invention to associate more than two individual retort chambers, say, for example, four or six, with a single common oil recovery conduit 22 and associated gas collecting conduit 24. In such case, a corresponding increase occurs in the number of branch oil pipes 26 and gas collecting pipes 30. Also, it will then be desirable to direct such branch pipes 26 and 30 for some short distance along the access entry 16 to arrive at their junction with the respective bases of a strategically located pair of concentric oil and gas conduits 22 and 24.

Within the scope of this invention, it may also be desirable to eliminate the gas collecting conduit 24, provided the surrounding formation is competent. In such case, a suitable annular space is provided between the oil recovery conduit 22 and the uncased bore hole through which such conduit 22 extends from the surface so as to accommodate the retort gases. Also, in such case suitable means will be provided to join the base of such uncased bore hole with the upper ends of the branch gas collecting pipes 30.

The shale oil evolved from a retorting operation as described will tend to thicken rapidly as it cools. Thus, one of the features of this invention is that constant heating is applied to the oil from the point of its collection at the base of the retort chambers to the point of its recovery to the surface. The closer a downwardly directed progressing combustion front moves toward the bottom of the retort chamber, the hotter the gases become which are evolved and hence the more effective will be the heating accomplished by the method of this invention.

Although the gas collecting conduits 30 may be tightly fitted within suitable openings in the bulkheads 34, it may be advisable to provide additional safeguards so that a positive pressure exists within the access entry 16 to protect working personnel against noxious gases, such as carbon monoxide. It will be convenient, therefore, to adjust the inflow of compressed air through each of air holes 20 in conjunction with the operation of the vacuum pumps 38 so that a slight vacuum is created at the bottom of each of the retort chambers 10

and 12.

Within the scope of this invention, it may further be desirable for ecological reasons or because of uneven terrain to confine the structural equipment normally positioned above the retort chambers **10** or **12** or like zones to an upper subterranean level. Thus, for example, the vacuum pumps **38** and the upper outlets of air holes **20,** oil recovery conduits **22,** and gas collecting conduits **24** can all fall within such a subterranean level.

From the foregoing it should be apparent that the practice of this invention permits many modifications of procedures and equipment to meet specific requirements and that such modifications will readily occur to those skilled in this art. While the operations described have particular reference to underground deposits of oil shale, it should be clearly understood that other underground deposits may be similarly treated.

What is claimed is:

1. A system for recovering carbonaceous values from an underground mineral deposit comprising:

a. at least one access entry extending substantially horizontally beneath the top of said deposit and communicating with the surface;

b. a plurality of designated adjacent zones within said deposit extending along at least one side of said at least one access entry in spaced relation thereto;

c. means for interconnecting the respective bases of said zones with said at least one access entry;

d. means for retorting said zones within said deposit adapted to release said carbonaceous values therefrom in liquefied form and to cause downflow thereof to the respective bases of said zones together with the gases evolved in said retorting operation;

e. sump means within said respective bases for collecting said liquefied values;

f. a plurality of spaced apart oil recovery conduits extending substantially vertically from the surface into said at least one access entry, the lower end of each of said conduits being thereafter branched to extend into said sump means of at least two of said zones through said interconnecting means; and

g. means for pumping said liquefied values from said sump means to the surface through said oil recovery conduits; and

h. means for scavenging said gases from the respective bases of said zones to the surface so as to apply continuous external heating to each of said oil recovery conduits.

2. A system as in claim **1** wherein said mineral deposit is oil shale.

3. A system as in claim **1** wherein means are provided for maintaining a predetermined overpressure within said at least one access entry relative to the bases of said permeable zones.

4. A system as in claim **1** wherein said scavenging means comprises a plurality of gas collecting conduits respectively surrounding at least a portion of the length of said oil recovery conduits in concentric relation thereto and extending into said zones.

5. A system as in claim **1** wherein said means for interconnecting the respective bases of said zones with said at least one access entry comprises a plurality of substantially horizontal tunnels of predetermined length extending laterally from said at least one access entry to said respective bases.

6. A system as in claim **5** wherein gas-tight sealing means are provided within each of said interconnecting tunnels between said at least one access entry and the bases of said zones.

7. A system as in claim **6** wherein each of said sealing means comprises a bulkhead through which a respective pair of said concentric conduits are adapted to pass.

8. A method for recovery of carbonaceous values from a permeable underground zone within a mineral deposit comprising the steps of:

a. inducing a downwardly directed heat front through the zone adapted to release said carbonaceous values therefrom in liquefied form and to cause downflow thereof to the base of the zone together with the gases evolved by said heat front;

b. collecting said liquefied carbonaceous values at the base of the zone;

c. separately conducting said liquefied carbonaceous values and said gas in a substantially horizontal direction from said base into a wellbore and thence to the surface, said wellbore being isolated from the heat of said zone; and

d. continuously heating said liquefied carbonaceous values by means of said gas throughout said conducting step.

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