

[54] **METHOD OF DEVELOPING A PERMEABLE UNDERGROUND ZONE**

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[58] Field of Search **299/2, 13, 19; 102/23**

[56] **References Cited**

UNITED STATES PATENTS

2,896,929	7/1959	Janelid et al.	299/13
3,611,933	10/1971	Lanning	102/23
3,661,423	5/1972	Garret	299/2

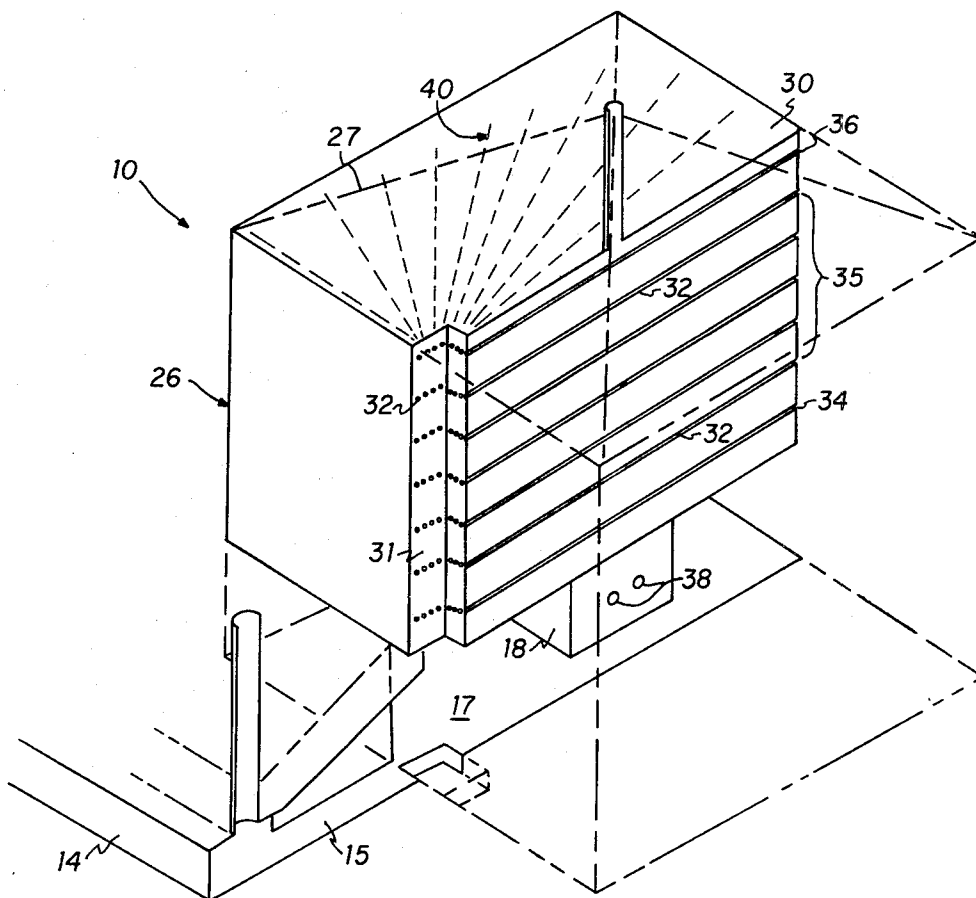
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[57] **ABSTRACT**

A subterranean ore deposit, such as oil shale, is undercut to form a cavity of predetermined void volume. A specific block of the deposit overlaying this cavity is designated together with an intermediate level thereof. From a suitable working space, explosively charged primary blasting holes are drilled substantially horizontally into the block so as to provide a uniform explosive charge distribution therein below the intermediate level. At least one secondary blasting hole is driven downwardly into the block from the surface of the earth or from an upper mining level and explosively charged above the intermediate level. The primary and secondary explosives are detonated in upwardly progressing timed sequence. This results in expansion of the overlying block into the cavity and fragmentation thereof in a cone-shaped configuration above the intermediate level.

11 Claims, 2 Drawing Figures



METHOD OF DEVELOPING A PERMEABLE UNDERGROUND ZONE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a method for forming permeable underground zones in an ore deposit and more particularly to a method for forming underground retorts in a deposit of oil shale.

2. Description of the Prior Art

In the art of in situ retorting of oil shale, it is conventional to form an underground retort by excavation and removal of a substantial portion of contained shale from the bottom of an upright retorting zone and thereafter to fragment the shale and allow it to expand into the void volume to produce a permeable, porous mass necessary to the movement therein of a vertically directed heat front.

An example of the application of this technique is found in U.S. Pat. No. 3,661,423 which describes an underground formation undercut by a cavity mined out by the room and pillar method. The pillars are explosively broken, and thereafter explosive charges in the overlayer are sequentially detonated from the bottom up so that the overlayer fragments and expands into the undercutting void. Although the method of this patent requires placement of explosive charges in the overlayer, it does not disclose from what vantage point the blasting holes are to be drilled nor does it indicate how such holes are to be oriented. However, when explosive fragmentation is employed in the preparation of a permeable zone in an underground ore deposit, it is essential that a method of blasting hole placement be devised which minimizes the working space required and which is of maximum effectiveness.

Typically upright "chimneys" forming permeable zones in an oil shale deposit may be retorted by igniting the shale at the top and inducing therein a downwardly moving heat front so as to pyrolyze the kerogen in the shale and release the carbonaceous values therein. In such an operation an inlet may be provided at the top of the retort through which a combustion supporting gas such as oxygen or air together with suitable fuel may be introduced. Evidence at this point is far from conclusive as to the manner in which the resultant combustion and heat fronts develop. However, it is hypothesized that the flow distribution pattern of the inlet air which governs the development and maintenance of these fronts is such that they do not expand to the full cross-sectional dimensions of the upright retort chimney or zone until they have progressed a significant distance in a downward direction. This distance appears to be dependent at least in part upon the bulk porosity of the fragmented ore and the initial "throw" effect of the inlet air stream. In that event, combustion may be occurring either incompletely or more slowly in much of the upper portion of a retort with a consequent failure to effectively recover carbonaceous values therefrom. It will thus be an economy to eliminate the time and expense involved in fragmenting portions of a block or deposit to be retorted which will be substantially unused. It has occurred to the inventor that this may be accomplished by controlling the blasting and fragmentation of the ore deposit and hence the dimensions of the retort zone itself.

It is not infrequently the case that a layer of oil shale of very low quality is found immediately above and ad-

jacent a layer of very high quality to be retorted in situ. The previous analysis suggests that the upper layer need only be expanded over a wide enough area to provide a gas flow path into the lower layer for establishment therein of a broad vertically directed heat front. Pyrolysis of the kerogen and the shale in the low quality upper layer will not contribute significantly to the total production of oil and indeed may be specifically undesirable. This suggests a further context, therefore, in which shaping of a retort zone may prove advantageous.

Finally, it may be observed that the blasting of an underground zone to create a retort chamber can be an expensive operation involving the drilling and loading of a large number of closely spaced blasting holes. It is, therefore, of interest to evolve a method of blasting which is adapted to produce a permeable zone of equivalent production potential to that of conventional chimneys but at less expense.

Prior art upright retorts employed in the above-discussed in situ retorting method are usually depicted in the form of a straight-walled chimney or cylinder. It has been suggested that explosive fragmentation of a subterranean zone within an ore deposit may be accompanied by a slight "doming" in order to improve the support provided by the overburden. But so far as the applicant is aware, no thought has been given to significantly modifying the shape of an upright retort for the purposes outlined herein or to devise means for accomplishing this result.

SUMMARY OF THE INVENTION

It is, therefore, a general object of this invention to provide an improved method for preparing a permeable underground zone for use in in situ retorting.

It is a more specific object of this invention to provide an improved method for preparing a permeable underground retort zone which minimizes the cost of blasting and fragmentation.

It is a still further object of this invention to prepare a permeable underground zone for in situ retorting of oil shale for more efficient recovery of the carbonaceous values thereof.

It is still another object of this invention to provide a method for preparing an underground retort in a formation of adjacent layers of oil shale of differing value.

In accordance with a preferred embodiment of the invention, the method comprises generally designating an underground zone within an ore deposit, undercutting a predetermined portion of said zone to form a cavity, providing substantially horizontally extending primary blasting holes within a lower portion of the zone overlying the cavity, drilling at least one downwardly directed secondary blasting hole from the top of the zone at least partially through the remaining upper portion of the overlayer, detonating the primary blasting holes in an upwardly progressing timed sequence from the bottom of the lower portion and thereafter detonating the secondary blasting hole. The expanding shock wave from the explosion of the secondary blasting hole working against the interface between the upper layer and the previously expanded lower portion of the overlayer causes cratering within the upper portion so that the resultant permeable zone, after expansion into the cavity, is cone-shaped at the top.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view of a pair of underground retort zones in different stages of development in accordance with this invention.

FIG. 2 is an isometric view (partially broken away) of a zone in an underground deposit being developed in accordance with this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference now to FIG. 1, there are illustrated two underground permeable zones 10 and 11, such as may be utilized as in situ retorts within a subterranean ore deposit 12, formed, for example, of oil shale or other carbonaceous material beneath an overburden 13.

The bottom end of the zones 10 and 11 communicate respectively with a horizontally extending access entry 14 by means of a pair of transverse zone entries 15. The zone 10 is shown in an intermediate stage of development while the zone 12 is shown in an expanded and permeable state suitable for retorting.

The invention will now be further discussed with particular reference to the zone 10, which comprises generally a block of ore 16 undercut by a cavity 17 and partially supported by one or more ribs 18 projecting into such cavity from the side walls thereof. The block 16 may be of any desired cross section, but for illustrative purposes it is here described and shown as being rectangular. The block 16 consists of an upper portion 24 (shown in dotted outline) and a lower portion 26 separated therefrom by an interface 30 at some predetermined intermediate level. The method of this invention is effective to fragment and render permeable a substantially cone-shaped segment or inverted crater within the upper portion 24 lying beneath the slanting outline 27 in proper timed sequence with the removal of the ribs 18 and the expansion of the entire portion 26.

Turning now to FIG. 2, an illustration of the lower portion 26 of the block 16 is shown overlaying the cavities 17 with the upper portion 24 removed.

From the roof of the cavity 17 at the point of its juncture with the zone entry, a raise 31 is driven upwardly along one vertical face of the zone 10 to a point adjacent the interface 30. The raise 31 may be driven by means of a so-called raise driver which is a form of self-propelled earth boring machine. Such machines are described, for example, in U.S. Pat. No. 3,399,738; and their construction and operation form no part of this invention. The common practice is to first drill a pilot hole through the earth's formation and the two points to be connected by a raise, after which the pilot hole is reamed out to the diameter of the finished raise.

A plurality of blasting holes 32 are drilled from the raise 31 along substantially horizontal paths into the lower portion 26 of the block 16 at a plurality of vertically spaced levels so as to effectively implant a bottom level 34, a plurality of intermediate levels 35, and a top level 36. Additionally horizontally extending blasting holes 38 are drilled into and at least partially through the ribs 18. As a practical matter, blasting holes 32 and 38 are driven at a slight upward slant to facilitate flushing out of cuttings and to eliminate standing water.

Blasting holes 32 at each of the levels 34, 35, and 36 extend radially from the raise 31 so that each blasting hole 32 is angularly separated from the most nearly ad-

jacent blasting hole 32 at such level. Also, the blasting holes 32 at any given level preferably extend or are projected to the periphery of the portion 26. A typical arrangement for the blasting holes 32 is illustrated by a fan-shaped pattern 40 superimposed for illustrative purposes in dotted outline on the interface 30.

The blasting holes 32 may be charged with suitable explosives so as to permit effective fragmentation of the portion 26. In order to achieve relative uniformity in the distribution of explosive charges over the cross-sectional area of the portion 26, it will be necessary to take account of the fact that the physical separation between adjacent blasting holes 32 increases with the distance from the raise 31. This problem may be dealt with in the manner covered in copending application, Ser. No. 499,697.

Referring now to the showing of FIG. 1, a conduit or blasting hole 44 is drilled downwardly from the surface of from an upper mining level into the block 16 for a predetermined distance. A selected quantity of explosive charge 46 may then be bulk loaded into the blasting hole 44, the amount and character of the explosive charge 46 being dependent upon the cross-sectional area of the zone 10 to be created and the character of the ore to be fragmented. If desired, the blasting hole 44 may be extended through the lower portion 26 or may even be drilled upwardly from the bottom. In that event, a plug 48, such as of wood, may be inserted within the hole 44 such that it will support a desired quantity of explosive charge 46 above it. In any event, the top of the explosive charge 46 will determine the approximate apex of the inverted crater to be formed within the upper portion 24. The entire explosive charge 46 is to be confined within the upper portion 24.

After all explosive charges are in place, a sequential detonation thereof is performed. This begins with removal of the ribs 18 followed by detonation of explosive levels 34, 35, and 36 in upwardly progressing sequence. As each of these levels is detonated and the adjacent ore fragments it creates a relatively free surface on the downside of the next layer above. Thus, when the ore adjacent level 36 expands, a relatively free surface exists at the interface 30. Thereafter the explosive charge 46 in the hole 44 is detonated, producing a crater within the upper portion 24 widening downwardly to the interface 30 in the cone-shaped path 27 at approximately a 45° angle. Clearly the height of the cone-shaped fragmented mass within the portion 24 depends upon the cross-sectional area thereof. For example, if the zone 10 has a cross-sectional dimension approximately 75 feet on a side, the height of the fragmented cone above the interface 30 will be on the order of 37½ feet and the remaining areas of the upper portion 24 above the path 27 remain unfragmented. If the location of the boundary between contiguous layers of differing characteristics within the ore deposit 11 is known, it will be in this manner possible to develop a permeable zone 10 having a cone-shaped top which widens to the full cross-sectional dimensions of such zone coincident with this boundary.

The zone 11 is shown interconnected with the zone entry 22 on the opposite side thereof from the zone 10. Here detonation and expansion of the contained ore deposit to fill the void volume of the cavity 17 have taken place. The conduit 44 at the top of the zone 12 now serves as a convenient means for introduction of compressed air and fuel in order to establish a downwardly directed combustion front. Since access means

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of this type will be required in any event in an upright retorting operation, the conduit 44 in accordance with this invention has the advantage of serving a dual purpose.

By shaping the zone 10 or zone 11 in the manner described, a considerable amount of material of the deposit 11 above the interface 30 has been left unfragmented. Aside from the positive advantages in retorting believed to result from this shape, this method eliminates the added cost which would be involved in extending the level of the primary blasting holes 32 upward to the top of the block 16. Drilling a downwardly directed hole 44 and inserting an explosive charge 46 therein as described above is a much simpler and cheaper operation.

Within the scope of this invention, a plurality of adjacent underground retorts may be developed and shaped wherein a plurality of vertically directed explosive-charged air holes as described extend downwardly into the deposit at spaced apart locations. If desired, it will also be possible to combine a plurality of such air holes within a single underground retort zone, such as zone 10 or 11. In that event, adjacent air holes 44 are conveniently spaced apart such that their respective bases overlap to form a continuous cross-sectional area of fragmented ore.

In some instances it may be desirable to produce an underground permeable zone or region within a carbonaceous deposit without employing the undercutting technique described above. It may, for example, be sufficient simply to alter the characteristics of a given zone by explosively fragmenting the ore mass and rendering it more porous. The method of this invention is applicable for such purposes even if the object is not specifically to "shape" the resultant zone or region.

From the foregoing it should be apparent that many alterations or modifications in the procedures described in connection with the preferred embodiment will occur to those skilled in this art without departing from the scope and spirit of this invention. In particular it is emphasized that while, for illustrative purposes, the method of this invention has been disclosed in connection with carbonaceous underground formations such as oil shale it may find utility with regard to other subterranean formations of differing character.

What is claimed is:

1. A method of developing and shaping a permeable zone within a subterranean ore deposit so that it will have a lower portion of substantially constant horizontal cross-section below a predetermined level from which it tapers upwardly to an apex to form a cone-shaped upper portion comprising the steps of:

- a. placing an explosive charge into the deposit adjacent said apex;

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b. expanding a volume of said deposit underlying said predetermined level to form said lower portion; and

c. thereafter detonating said explosive charge to produce cratering of said deposit between said apex and said predetermined level so as to form said upper portion.

2. A method as in claim 1 comprising placing said explosive charge within a blasting hole drilled into said deposit in a substantially vertical direction.

3. A method as in claim 2 wherein said blasting hole extends downwardly from the surface of the earth.

4. A method as in claim 2 wherein said blasting hole extends downwardly from an upper mining level.

5. A method as in claim 2 wherein said blasting hole extends upwardly from the bottom of said lower portion.

6. A method as in claim 1 wherein said ore deposit is a carbonaceous material.

7. A method as in claim 1 wherein said ore deposit is oil shale.

8. A method of forming an upright retort in a subterranean ore deposit wherein the base of the deposit is partially undercut to form a cavity therebeneath connecting with the surface, a designated block of the overlaying deposit being thereafter expanded to fill said cavity, the improvement comprising the steps of:

- a. providing a substantially vertically directed blasting hole extending into said block so that said blasting hole lies at least partially above a predetermined level of said block;

- b. charging said blasting hole with a length of explosive above said intermediate level;

- c. explosively fragmenting the portion of said designated block below said intermediate level to effect expansion thereof into said cavity; and

- d. thereafter detonating the explosive in said blasting hole to produce a downwardly widening crater of fragmented material of said designated block extending from the top of said explosive to said intermediate level.

9. A method as in claim 8 wherein said blasting hole is approximately centered within the cross-sectional dimensions of said designated block.

10. A method as in claim 8 wherein said at least one blasting hole is connected to a source of air and fuel adapted to ignite said fragmented ore.

11. A method as in claim 8 wherein said ore deposit comprises an upper low quality layer lying above and contiguous with a lower high quality layer and wherein said intermediate level of said detonated block is situated at the interface between said low and high quality layers.

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