United States Patent [19]

Davis, II

[11] **3,716,272**

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[54] **METHOD OF CREATING LARGE DIAMETER CYLINDRICAL CAVITIES BY SOLUTION MINING**

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[21] Appl. No.: **148,255**

[52] **U.S. Cl.** **299/5**

[51] **Int. Cl.** **E21b 43/28**

[58] **Field of Search** 299/4, 5

[56] **References Cited**

UNITED STATES PATENTS

3,596,992	8/1971	Dietz	299/5
3,632,171	1/1972	French et al.	299/5
3,574,402	4/1971	Davis et al.	299/5
2,009,534	7/1935	Trump	299/5
3,096,969	7/1963	Edmonds et al.	299/4

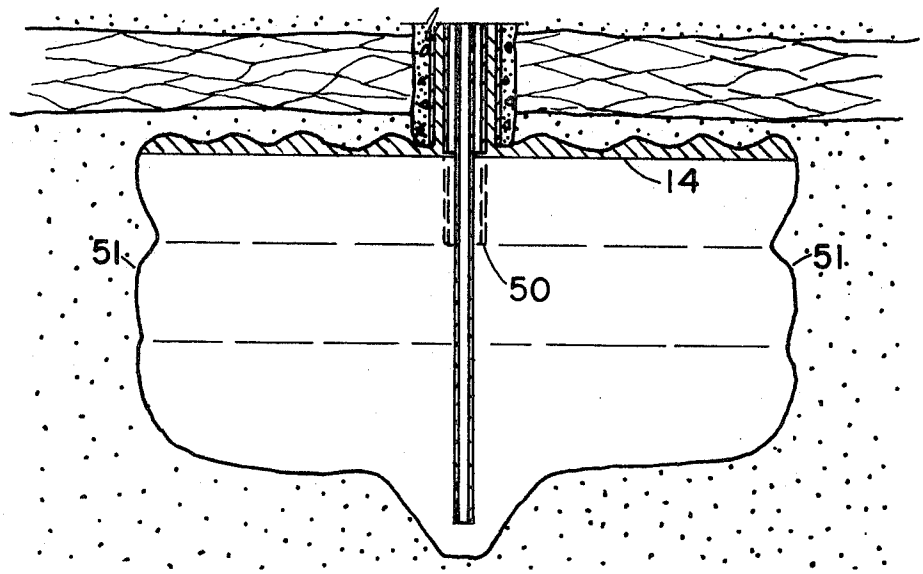
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[57] **ABSTRACT**

A method for forming a subterranean cavity including the steps of drilling and casing a hole to the depth desired for the roof of the cavity, then deepening the hole to a depth to about 4 feet below the floor level, positioning a dual string of wash pipe with the injection string at the desired floor level and the production string at the bottom of the hole, creating a horizontal hydraulic fracture at the floor level using fresh water and extending the fracture out a distance desired for the radius of the cavity, injecting a protective blanket over the roof of the cavity, and solution mining the cavity in incremental stages, maintaining the protective blanket for each incremental stage.

3 Claims, 3 Drawing Figures



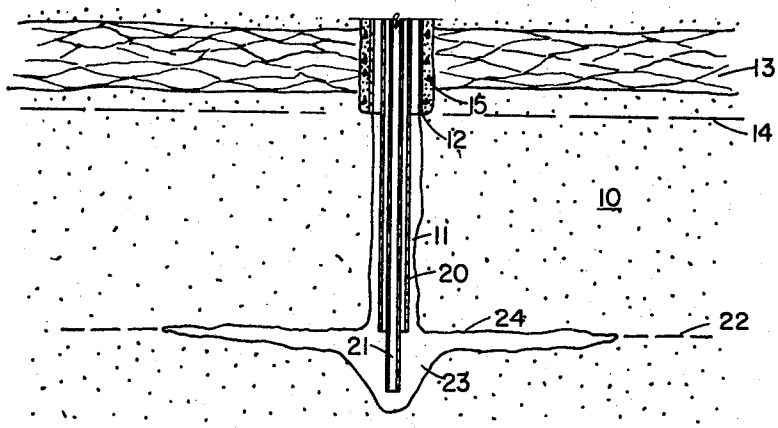


FIGURE 1

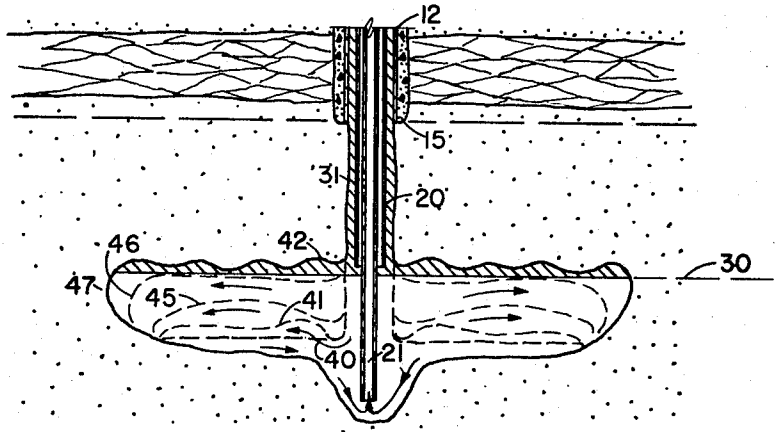


FIGURE 2

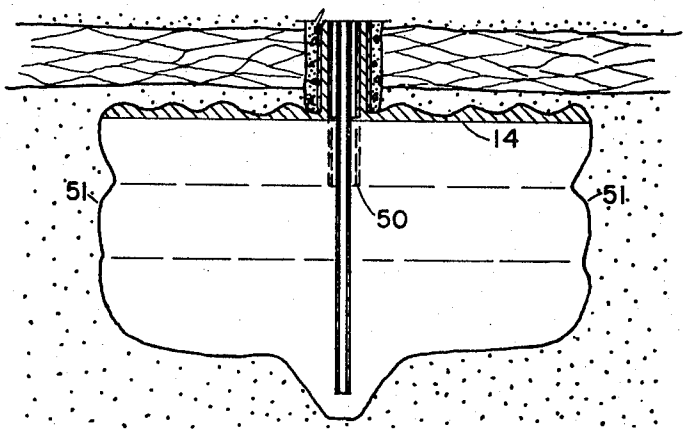


FIGURE 3

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METHOD OF CREATING LARGE DIAMETER CYLINDRICAL CAVITIES BY SOLUTION MINING

PRIOR ART

Methods of solution mining using one or more drilled holes have become well established in the art.

Single hole methods have generally included a rotating jet as shown in the patent to Dahms et al., U.S. Pat. No. 3,402,965.

Two wells are also commonly incorporated, such as that illustrated in the patent to Hendrix et al., U.S. Pat. No. 2,880,587.

In the two-well system, a fracture is generally formed between the injection well and the production well, and fluids are passed between each well along the fracture line dissolving the salt above and below the fracture.

It is also common practice as shown in the patent to Tracy, U.S. Pat. No. 1,960,932, to case a well, pass fluids down the outer casing, and draw the solution up an inner casing; however, the method shown by Tracy forms a cavern which resembles an inverted cone since the cavity is growing outward from the originally drilled hole and all solution is taking place on the cavity wall closest to the inlet pipe. The wall soon becomes semiprotected from the solvent by a layer of saturated brine and clay and other insoluble materials that settle out as the salt is dissolved.

OBJECTS AND FEATURES OF THE INVENTION

This invention features a method for forming a large diameter cavity having substantially vertical walls rather than the inverted cone shape of the prior art cavities. The cavity will, as a consequence, afford the maximum amount of mined material from a given location or the maximum amount of storage capacity if the cavity is intended for storage purposes such as, for example, propane. Thus, the limiting cavity diameter can be substantially increased for a given cavity height. Furthermore, the rate of mineral solution can be greatly increased, thus allowing a much greater volume to be mined per drill hole and decreasing the time required to mine the desired volume. As a consequence to the above, the total amount of soluble material that can be recovered per unit volume of solvent injected can be substantially increased.

These and other features are accomplished by drilling a hold into a formation to a depth desired for the cavity floor. The hole thus drilled is then cased to a depth desired for the final roof of the cavity or for the maximum height of the material to be mined. The hole is then deepened about 4 feet below the desired floor level and a dual string of wash pipe is inserted into the drilled hole with the injection string terminating at the desired floor level and the production string terminating at the bottom of the hole (which was deepened four feet). A protective blanket of water insoluble material is then passed down the outside of the injection pipe and permitted to flow up the pipe indicating the area between the injection pipe and the drilled hole is full of water insoluble material. A 6 foot diameter cavity is then solution mined for use as a hydraulic fracture initiation notch as described in U.S. Pat. No. 3,574,402. Other forms of notching can be used, for example, mechanical notching tools. A horizontal hydraulic fracture is then created at the floor level using fresh water. The fracture is driven out to a radius desired for the cavity which could be as large as 100 feet. The injection pipe is then raised an incremental distance above the hydraulic fracture, for example, four feet, and the protective blanket formed as previously described. Solution fluid is then passed down the injection pipe and removed by the production pipe. Periodically, production may be stopped and the protective blanket reformed as previously described, or the protective blanket fluid can be continuously injected down the pipe and the production stream monitored to determine the proper quantities of blanket fluid. The solution will cause the cavity to form further and further away from the injection pipe, the protective blanket preventing the fresh water from dissolving any of the formation until the water reaches the sides of the cavity.

To raise the height of the cavity or to continue mining, the injection pipe is again raised and the protective blanket reformed and the process repeated. The injection pipe will be raised as many incremental units as needed to form the maximum height of the cavity or to mine all of the material.

BRIEF DESCRIPTION OF THE DRAWING

Referring to the drawing,

FIG. 1 illustrates the relationship of the casing, the drilled hole, the injection pipe, the production pipe, and the fracture in a formation where a cavity is to be formed.

FIG. 2 illustrates the formation of the initial cavity.

FIG. 3 illustrates the completed cavity.

SPECIFIC DESCRIPTION OF THE FIGURES

Referring to FIG. 1, a soluble formation **10**, which could be by way of example sodium chloride or potash ore, has a hole **11** drilled therein. A pipe **12** cases the hole **11** in the formation **13** down to the intended cavity roof **14**. Casing **12** may be cemented as illustrated at **15**. Inserted within casing **12** is an injection pipe **20**, and inserted coaxially within the injection pipe is a production pipe **21**. The floor, illustrated by dotted lines **22**, is deepened at **23** to facilitate removal of the saturated solution, and the injection pipe **21** lowered into the deepened portion **23**. A fracture **24** is then formed using water under hydraulic pressure and extends out a distance desired for the radius of the cavity.

Referring to FIG. 2 the production pipe is then raised a first incremental distance **30** and a protective blanket is formed by passing a water insoluble material **31** down the casing until the material begins to flow up the injection pipe **20**. The water insoluble material must be of lower specific gravity than the water or solvent and should be substantially immiscible therewith in order to maintain a proper protective blanket, and may be, for example, hydrocarbon, LPG, or other suitable material. The formation of the cavity begins by passing fresh water down the production pipe and into the formation in the direction of arrow **40** which will dissolve the formation. The saturated solution, being heavier, will fall to the bottom of the cavity where the solution will pass up pipe **21**. The water insoluble material will prevent the fresh water near the injection pipe from eroding away the area around the hole. Since the fresh water has a specific gravity less than that of the saturated water, the fresh water will tend to stratify between the

saturated solution and the protective blanket, causing the fresh water to move to the side of the cavity where the water will have maximum protection to dissolve the sides of the cavity.

After a period of time as indicated by the dotted lines **41**, the process of injection may be stopped and the water insoluble material again injected into the well as shown by material **42** until it again flows up the injection pipe **20** and extending the protective blanket. Solution mining is again commenced until a point in the formation of the cavity is reached as indicated, for example, by line **45** where the protective blanket process is again repeated. Increments **46** and **47** will then be required to extend the cavity to its maximum diameter.

The above process of rebuilding the protective blanket in stages can be repeated by continuously injecting the blanket fluid and monitoring the production stream for evidence of the fluid.

Referring to FIG. **3**, when the cavity reaches its maximum diameter, the injection pipe **20** is raised to a new position **50**, and the process as above described is repeated extending the second increment out to the maximum diameter **51** of the cavity.

The maximum height of the cavity can eventually be reached by sufficient number of incremental positions of pipe **20** until the pipe is finally to the desired height **14** of the roof of the cavity. At this point the injection pipe **20** will be substantially even with the bottom of the casing **12**.

The process is again repeated until the cavity roof is extended out to the maximum diameter of the cavity.

It is obvious that the shorter the increments that are selected, the more nearly straight will be the side walls. The ideal increments for solution mining the maximum product with the minimum water or solvent usage will depend upon the particular mineral being mined and the solvents used.

It is further obvious that changes and modifications can be made in the increment distances selected, the solvents, the blanket protection material, and in the number of sequential extensions of the blanket protection and still be within the spirit and scope of this invention.

I claim:

1. A method for forming a subterranean cavity including the steps of drilling and casing a hole to the depth desired for the roof of the cavity, then deepening the hole to a depth to about 4 feet below the floor level, positioning a dual string of wash pipe with the injection string at the desired floor level and the production string at the bottom of the hole, the improvement comprising creating a horizontal hydraulic fracture at the floor level using fresh water and extending the fracture out a distance desired for the radius of the cavity, injecting a protective blanket over the roof of the cavity, and solution mining the cavity in incremental stages, maintaining the protective blanket for each incremental stage.

2. A method as described in claim **1** wherein said protective blanket is continuously injected over the roof of the cavity while said solution mining is taking place.

3. A method as described in claim **1** wherein said solution mining of the cavity during each incremental stage is performed in sequences of

a. inserting a protective blanket over the roof of the cavity,

b. solution mining the cavity to a greater diameter, and

c. repeating steps a and b until the desired diameter of the cavity is reached.

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