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Fraser et al.

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[54] **METHOD FOR THE SUBTERRANEAN STORAGE AND WITHDRAWAL OF A LIQUID**

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[51] **Int. Cl.** **B65g 5/00**

[58] **Field of Search** 61/.5; 166/294

[56] **References Cited**

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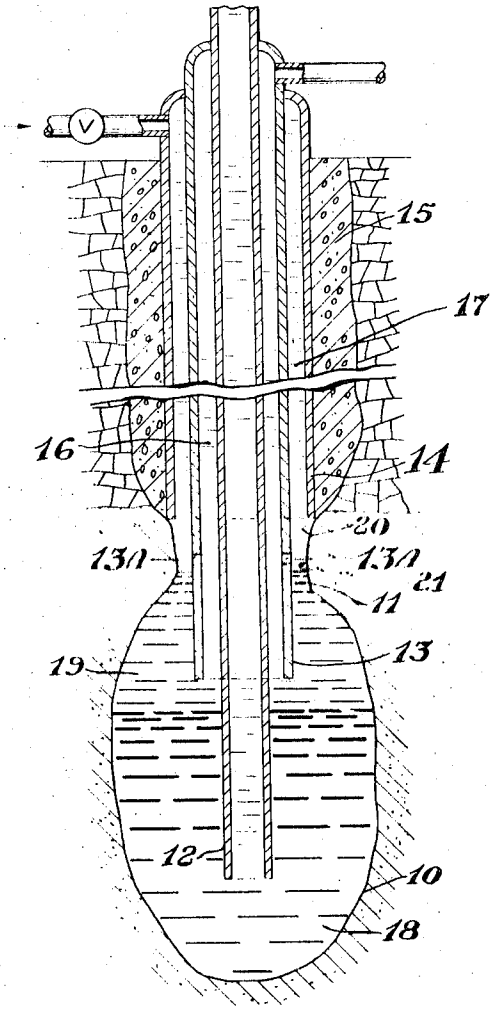
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[57] **ABSTRACT**

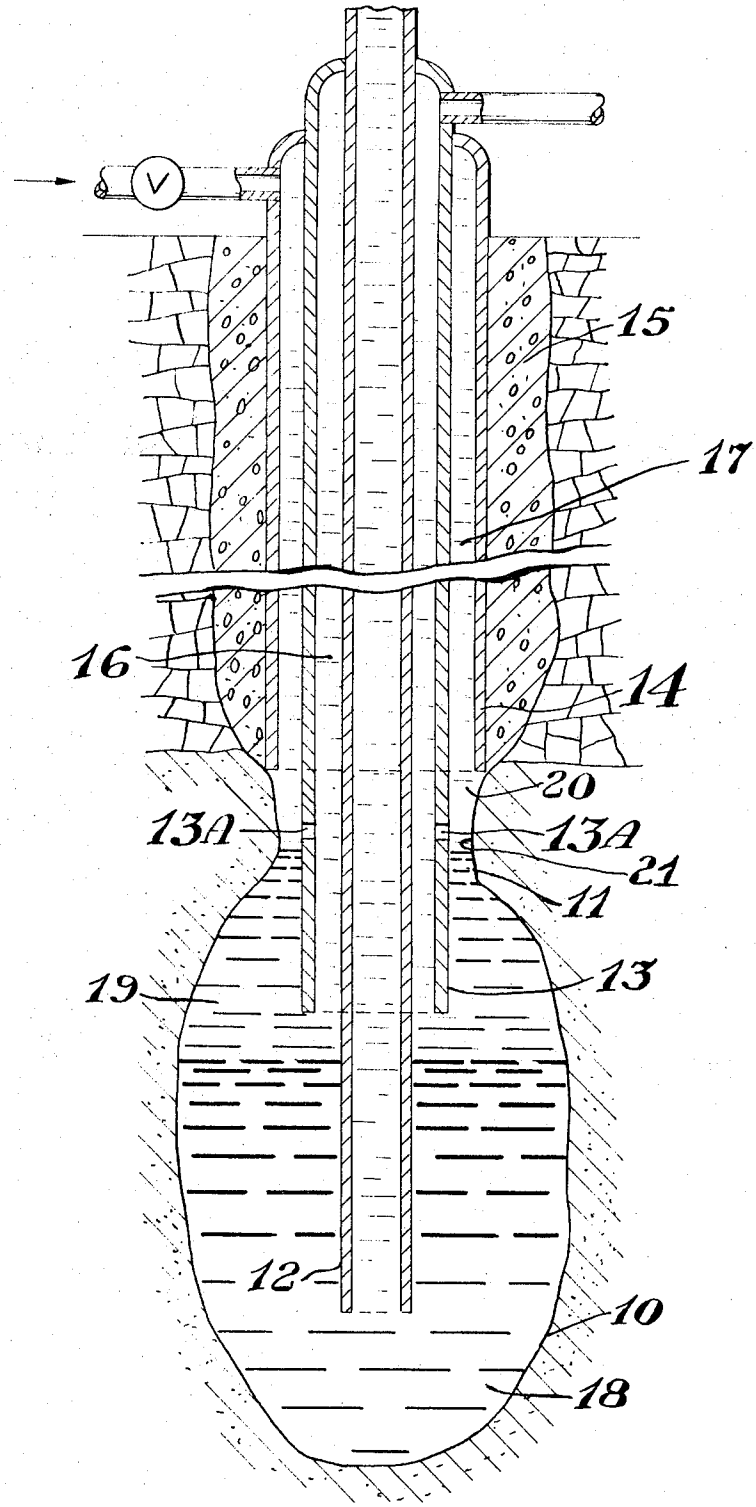
Three concentrically displaced conduits are supported in a borehole connecting the surface of the earth with a storage cavity. The first smaller and inner conduit descends to a short distance from the bottom of the cavity. The second next larger conduit descends a short distance below the roof of the cavity. The third and largest conduit is cemented into the borehole wall and descends to a distance above the roof of the cavity leaving a portion of the borehole wall exposed. The stored liquid fills the first conduit and a portion of the cavity. A displacing luqiid, less dense than the stored liquid, fills the remainder of the cavity and the annular space between the first and second conduit. A sealing luqiid which is not harmful to the formation and which is less dense than the displacing liquid, fills the annular space between the second and third conduit and also a major portion of the exposed portion of the borehole wall.

4 Claims, 1 Drawing Figure



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METHOD FOR THE SUBTERRANEAN STORAGE AND WITHDRAWAL OF A LIQUID

BACKGROUND OF THE INVENTION

In storing certain liquids in a subterranean cavity either the displacing or storage liquid may erode or otherwise weaken portions of the borehole wall which support connecting conduits. It may not always be possible or practical to case the entire borehole wall. Therefore, a portion of the supporting formation remains exposed and is subject to erosion or other weakening effects.

In the present method a liquid seal is provided to protect an exposed formation wall located in a borehole communicating with a storage cavity.

DESCRIPTION OF THE DRAWING

The FIGURE shows in schematic section a storage cavity employing the principles of the present invention.

DESCRIPTION OF THE INVENTION

In the practice of the present invention there is provided a storage cavity **10** connected to the surface of the earth by a borehole **11.** The cavity can be prepared in any desired manner such as by dissolving a salt formation or the like. Supported in the borehole are three concentrically arranged conduits. The first or inner most conduit **12** descends to a short distance above the bottom of the cavity. The second conduit **13** descends to a distance slightly below the roof of the cavity and is provided with aperatures **13A** through the wall thereof at a distance which is above the roof of the cavity but below the end of the third conduit **14.** The third conduit **14** is supported in the borehole by cement **15.** The three conduits form first and second annular spaces **16** and **17** which communicate between the cavity and the surface of the earth. The ends of the conduits above the surface of the ground are connected to pumping, shut-off and supply equipment (not shown) well known in the art.

Three liquids are employed in the practice of the invention. The stored liquid **18** has the greatest density and, therefore, occupies the lower-most portion of the cavity. The stored liquid is introduced into and withdrawn from the cavity **10** through the first conduit **12.**

The displacing liquid **19** is less dense than and substantially immiscible with, the stored liquid and is introduced into and withdrawn from the cavity through the first annular space **16.**

A sealing liquid **20** occupies the major portion of the second annular space **17.** The sealing liquid is one which is less dense and substantially immiscible with the displacing fluid **19** and in addition is non-reactive with and will not dissolve the formation face **21** and cement **15** which is located between the lower end of conduit **14** and the aperatures **13A** located in the second conduit. In this manner the formation and cement supporting the third conduit **14** are not eroded away or otherwise weakened through the action of the displacing liquid **19.**

In operation the storage cavity is employed in the following manner. First, the cavity is filled with the displacing fluid **19.** The sealing liquid is then transported into the second annular space **17** to displace the displacing liquid therefrom.

The sealing liquid is pumped into the second annular space **17** until traces of it appear in the displacing liquid which is sampled from the first annular space **16,** thus indicating that it is passing through the openings **13A** in the second conduit **13.** Thus, substantially all the displacing liquid has been replaced by sealing liquid in the second annular space. The sealing liquid is shut in by closing a valve so that pressure from the other liquids will not force it from the second annular space. Other means may be employed to determine when the second annular space is filled with the sealing liquid.

The stored liquid **18** is then transported through the first conduit **12** whereupon it displaces a corresponding volume of the displacing liquid **19** through the first annular space **16.**

To remove stored liquid, displacing liquid is transferred under pressure through the first annular space **16** to force the stored liquid up through the first conduit **12.**

Periodically the liquid seal is checked, such as by introducing additional sealing liquid into the second annular space **17** until traces of it are observed in the displacing liquid located in the first annular space **16** to assure a constant protection of the formation face.

This method may be employed to store liquids such as halogenated hydrocarbons, e.g. ethylene dichloride, wherein the displacing liquid comprises a brine or other less dense liquid. The sealing liquid may comprise petroleum oils, e.g. fuel oil, diesel oil, etc.

Ethylene dichloride is stored in a cavity formed in a salt dome in the following manner. The inner or first conduit has an outside diameter of about 4 ½ inches and descends into the cavity a short distance from the bottom thereof. The second conduit has an outside diameter of about 7 inches and extends into the cavity a distance of about 10 feet. The third or outside conduit having an outside diameter of about 9 ⅝ inches is cemented to the borehole wall and ends about 222 feet from the roof of the cavity. The second conduit is notched about 2 feet up from the top of the cavity to provide communication through the wall thereof. The cavity is first filled with brine and a seal is provided in the annular space between the second and third conduit by pumping diesel oil therein until it shows up in the brine circulated from the first annular space located between the first ad second conduit. The cavity has a capacity to hold about 958,000 barrels (42 gal/bbl) of liquid. Ethylene dichloride is introduced into the cavity through the first conduit and displaces brine through the first annular space. About 125 million pounds of ethylene dichloride are stored in the cavity in this manner.

What is claimed is:

1. A method of storing liquid in an underground cavity connected to the surface of the ground by a borehole wherein a portion of formation face of said borehole is exposed to liquids which comprises:

a. supporting in said borehole is a concentric arrangement at least three conduits comprising a first, second and third conduit, wherein said conduits communicate with the surface of the ground and wherein said first conduit has the smallest diameter and descents into the cavity a short distance from the bottom thereof, said second conduit is larger than the first conduit and smaller than the third conduit and descends into the cavity a short distance below the roof of said cavity to form a first annular space between said first and second conduits, said second conduit having at least one open-

ing through the wall thereof located a distance near the roof of the cavity and below the cemented portion of the third conduit, and said third conduit is cemented in the borehole and descends to a distance above the roof of said cavity to leave a portion of the formation face of said borehole exposed between the lower end of said third conduit and the roof of said cavity to form a second annular space between said second and third conduits and said exposed portion of the formation located between the lower end of said third conduit and the roof of said cavity;

b. filling the cavity, the first conduit and the first and second annular spaces with a displacing liquid;

c. transferring a sealing liquid which is less dense than the displacing liquid into the second annular space until said second annular space is filled with the sealing liquid to replace all the displacing liquid in said second annular space, said sealing liquid being non-detrimental to the cement employed to support the third conduit in place in the borehole and to the exposed formation face; and

d. transferring a volume of liquid to be stored which is denser than said displacing liquid into the cavity through the first conduit to displace a corresponding volume of displacing liquid from the cavity and leaving a column of said storage liquid in said first conduit.

2. The method as defined in claim **1** wherein the cavity is located in a salt formation, the displacing liquid is a brine and the sealing liquid in the second annular space is a liquid hydrocarbon.

3. The method as defined in claim **2** wherein the liquid to be stored is a halogenated hydrocarbon.

4. The method as defined in claim **1** wherein the displacing liquid is a brine, the storage liquid is ethylene dichloride and the sealing liquid is a liquid hydrocarbon.

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