United States Patent

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[54] **METHOD OF RECOVERING STORAGE VOLUME IN AN UNDERGROUND CAVERN**
6 Claims, 1 Drawing Fig.

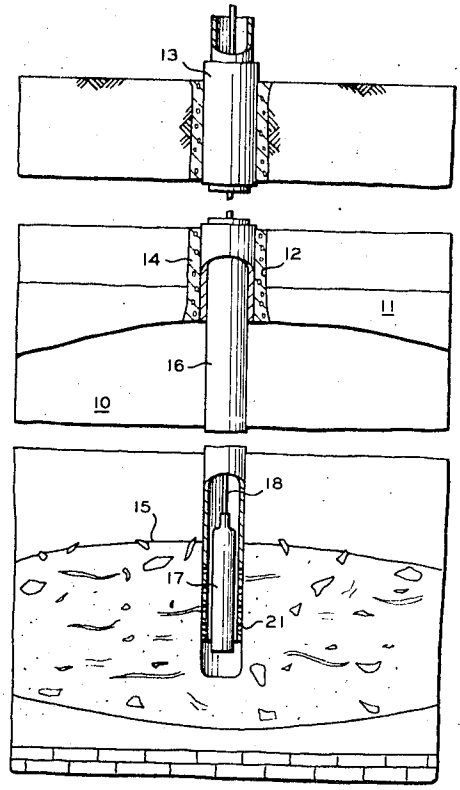
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[50] Field of Search: 299/4, 5; 61/.5

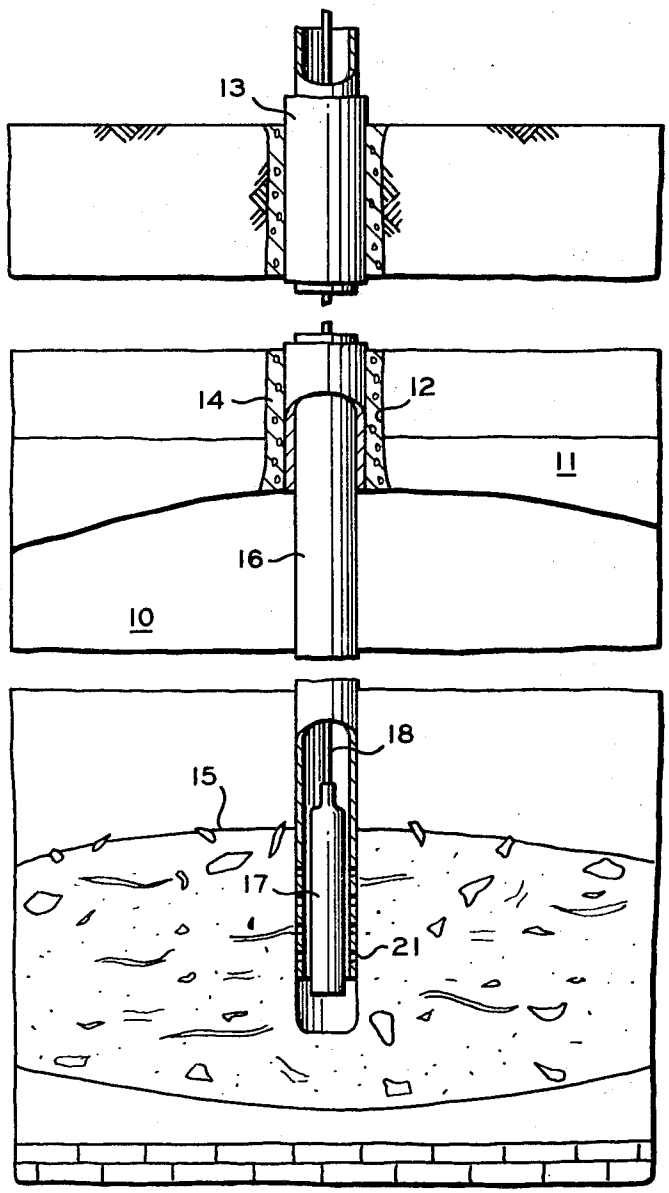
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ABSTRACT: Storage volume lost in an underground storage cavern as a result of debris collecting at the bottom thereof is recovered by lowering a casing string to a position adjacent the top of the debris, drilling into the debris through the casing string, advancing the casing string into the drilled hole, and thereafter recovering material from the cavern.





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METHOD OF RECOVERING STORAGE VOLUME IN AN UNDERGROUND CAVERN

BACKGROUND OF THE INVENTION

It is now common practice to provide underground storage caverns for hydrocarbons, ammonia and other fluids. Typically, these caverns are formed in a soluble formation, such as a salt bed. In dissolving or otherwise forming a cavern, a certain amount of insoluble debris accumulates at the bottom, for example, from pieces of shale or anhydrite which may be present in the soluble formation. After formation of the cavern, additional debris oftentimes falls from the top and sometimes damages or severs the tubing utilized for introduction of the stored material into the cavern and removal therefrom. Since the tubing could not be lowered below the top of the debris, there was loss of storage space represented by the voids within the layer of debris. Also, it has not been possible to recover the material accumulating within these voids, whether it be stored fluid or displacement liquid.

BRIEF STATEMENT OF THE INVENTION

In accordance with my invention, a casing string is lowered to a position adjacent the top of the layer of debris. A drill bit is inserted through the casing string and a hole is drilled into the debris. Thereupon, the casing string is advanced into the drilled hole. This enables recovery of the storage space represented by the voids in the layer of debris.

DETAILED DESCRIPTION OF THE INVENTION

The invention will become further apparent from the following detailed description taken in conjunction with the accompanying drawing, in which:

The FIGURE is a schematic diagram in vertical section illustrating the application of the invention to an underground storage cavern.

Referring now to the FIGURE, I have shown an underground storage cavern **10** formed in a soluble formation **11**, such as salt. The cavern described herein is utilized for the storage of hydrocarbons, such as propane, although the invention is applicable broadly to underground storage caverns provided for the storage of other fluids such as ammonia or butane.

Communication between the surface and the cavern **10** is effected by a drilled hole **12** within which is disposed a string **13** of casing supported within the hole by a body **14** of cement filling the annulus between the hole and casing.

A layer **15** of insoluble debris is shown at the bottom of the cavern **10**. This debris consists of impurities such as large pieces of shale, anhydrite or other minerals. Ordinarily, part of the debris accumulates during the original formation of the cavern while the rest of it falls from the roof during subsequent use of the cavern.

Material to be stored is introduced into or removed from the cavern by a string of tubing, not shown. For example, in a propane storage cavern, brine may be pumped into the tubing to displace stored material from the cavern whence it passes through the annulus to the surface. When additional propane is to be stored, it is pumped through the annulus, thus displacing brine through the tubing.

It will be evident that the tubing could not heretofore be inserted below the top of the layer **15** of debris. Also, in some cases, debris falling from the roof has damaged or severed the tubing after the cavern was placed in operation. It is further evident that the area occupied by the debris is lost for storage purposes, and that stored or displacement material accumulating within the voids in the layer of debris could not be recovered due to the difficulty of displacing it from the void spaces.

In accordance with the invention, I recover the storage volume represented by the voids in the debris and permit this volume to be utilized for storage purposes. To this end, I lower a casing string **16** through the casing **13** to a region adjacent the top of the layer **15** of debris. Thereupon, a drill stem and bit **17** is inserted through the casing string and a hole is drilled into the layer of debris, preferably by reciprocation of a cable **18**. Preferably but not necessarily, the hole is drilled with cable tools because such holes ordinarily are of larger diameter than the diameter of the casing string. Thereupon, the casing string is lowered into the drilled hole, the drill bit is removed, and stored material is recovered from the cavern. This permits the voids in the layer **15** of debris to be utilized for storage purposes.

As stated, cable tools ordinarily drill a larger hole than that formed by the drill bit so that the casing can be introduced thereinto without any difficulty. However, it is within the scope of the invention to utilize rotary tools, in which case it may be necessary to ream the portion of the hole below the casing string **16**.

Depending upon the depth of the debris layer, it is oftentimes desirable to repeat the steps of drilling and advancing the casing string. Thus, a hole is drilled a few feet into the debris layer, the casing string is advanced into the hole, and a further length of hole is drilled. These steps are repeated until the casing penetrates to the desired depth within the layer of debris. Most advantageously, of course, the hole is drilled and the casing advanced to a region adjacent the bottom of the cavern, thereby enabling maximum utilization of the storage volume.

It is a feature of the invention that the lower end of the casing string may be slotted or perforated, as indicated at **21**. In this fashion, when total depth has been reached, the casing can be flushed and backflushed to remove silt and fine sand from the region adjacent the slotted or perforated end of the pipe. This provides access to the voids in the layer **15** of debris, allowing displacement fluid therein to be replaced by hydrocarbons.

It will be apparent that I have achieved the objects of my invention in providing a method of recovering storage volume in an underground cavern which has heretofore been lost as a result of debris collecting at the bottom of the cavern. The cost of recovering storage space by this method is only a fraction of the cost of providing new storage, as by dissolving additional caverns in soluble formations. Also, the storage volume can be recovered by my method in only a fraction of the time required to construct additional storage facilities.

Other variations and modifications of this invention will be apparent to those skilled in the art without departing from the spirit and scope of the invention.

I CLAIM:

1. In a method of recovering storage volume in an under ground cavern which has been lost as a result of debris collecting at the bottom of the cavern, the steps of lowering a casing string to a position adjacent the top of the debris, inserting a drill bit through the casing string and drilling a hole into the debris, advancing the casing string into the drilled hole, removing the drill bit to permit the recovery of fluid from the voids in said debris.

2. In the method of claim **1**, repetitively drilling increments of hole into the debris and advancing the casing string into the drilled hole.

3. In the method of claim **2**, providing perforations at the lower end of the casing string, and flushing fine material from the volume surrounding the lower section after it has been advanced the desired amount into the debris.

4. The method of claim **3** wherein the drilling is effected with cable tools and the hole extends to within a short distance of the bottom of the cavern.

5. The method of claim **4** wherein the cavern is formed in a salt formation, said cavern contains a light hydrocarbon material stored therein and including the step of recovery of said light hydrocarbon through the casing string.

6. The method of claim **5** wherein the light hydrocarbon is propane.