

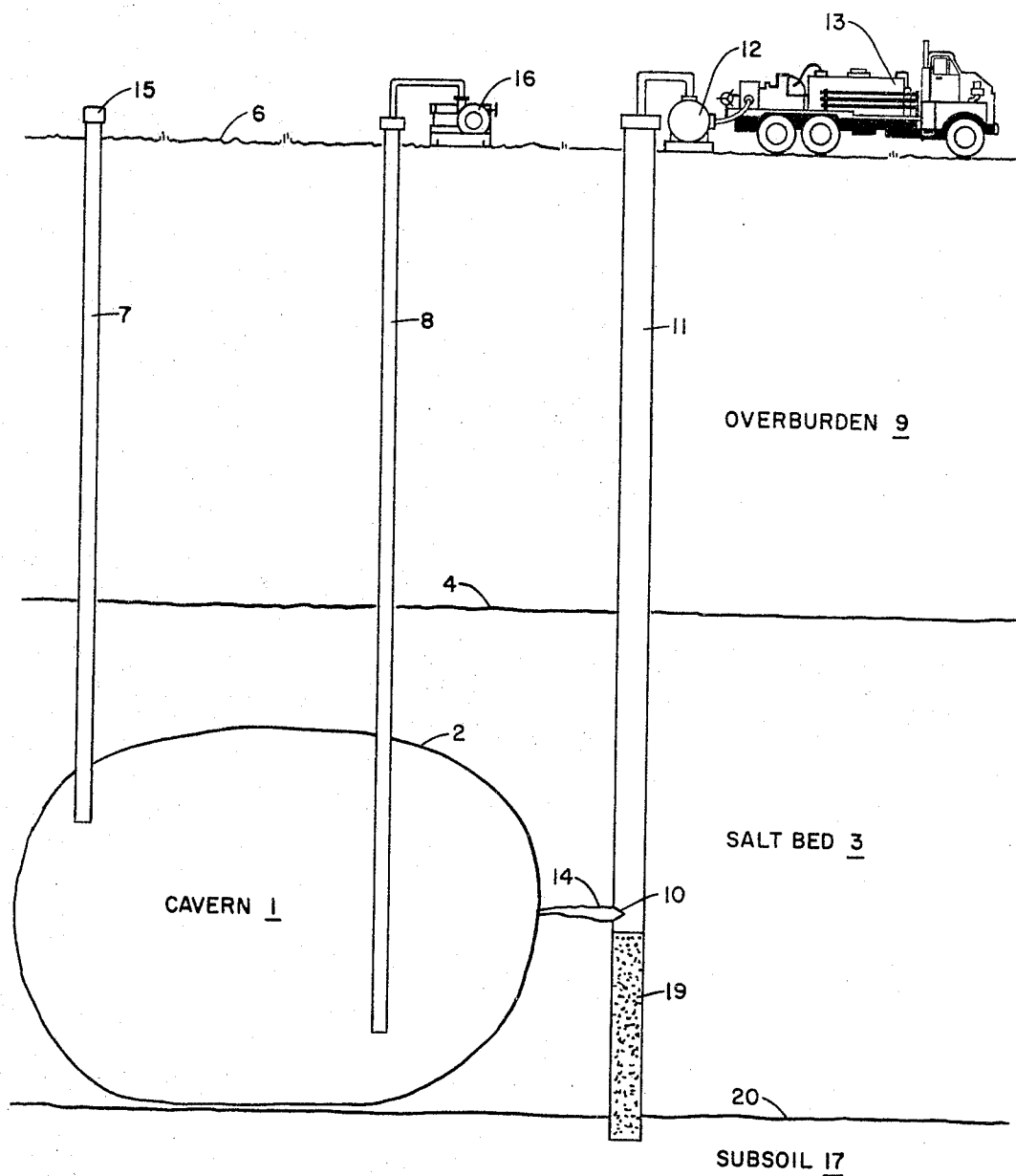
July 4, 1967

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3,329,207

FRACTURING INTO A CAVITY

Filed March 12, 1965



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3,329,207

FRACTURING INTO A CAVITY

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Filed Mar. 12, 1965, Ser. No. 439,164

2 Claims. (Cl. 166—42)

ABSTRACT OF THE DISCLOSURE

In fracturing into a preformed cavity, for example into a cavity in a salt formation where said cavity has been washed out to the point where additional solution becomes uneconomical, from a well remote from the cavity, for example where it is desired to start a new injection point for the solvent, the preformed cavity is pressurized to relieve the compression stresses in the cavity wall but below the pressure which would initiate fracture, and thereafter initiate fracture from the well toward the cavity.

This invention relates to solution mining. In one aspect this invention relates to a method of fracturing into a preformed cavity. In another aspect this invention relates to a method of controlling the lateral direction of cavity growth.

It is well known in the art to remove minerals from underground deposits via solution mining. After prolonged operations a cavity is created, and it becomes more and more difficult to contact the face of the soluble material with fresh solvent. Also, it is virtually impossible to control the direction of cavity growth. Several methods have been proposed for controlling the cavity roof and even for bringing fresh solvent into contact with the salt to be dissolved out. In general, these methods suggest using a lower or heavier specific gravity nonsolvent and nonmiscible with the solvent, thus confining the solvent to the level desired. Still other methods teach spraying the solvent onto the walls of the cavity, collecting the salt enriched solvent at the bottom of the cavity and recovering same. However, there has been no really effective means developed for directing cavity growth in a horizontal direction. One obvious method of directing cavity growth is to drill a well spaced from the cavity fracture into said cavity and enlarge the fracture by contacting the salt adjacent to the fracture with fresh solvent. However, with all the present known techniques of directional fracturing, it has been virtually impossible to fracture into an existing cavity. Although such a fracture will start in the desired direction, the fracture will inevitably proceed away from the cavity. We have found a suitable method for fracturing into such an existing cavity.

It is, therefore, an object of this invention to provide a means of fracturing into a preformed cavity. It is another object of this invention to provide a means of directing the growth of an underground solution mining cavity. Other objects and advantages of this invention will be obvious to those skilled in the art from this specification and the claims.

These objects are obtained by drilling a well a spaced distance from the cavern, pressuring the cavern to at least the overburden pressure and directionally fracturing into said cavern from said well.

As has been pointed out, fracturing into a cavern or cavity is extremely difficult. Although we do not wish to be bound by any theory, we believe that the walls of the cavern are unduly compressed since they must support the overburden of the entire cavern. When we pressure the cavern to the overburden pressure, about

equal to the calculated hydrostatic head for the depth or about ½ pound per foot of depth, this strain at the wall of the cavern is relieved and the fracture can be made to travel into the cavern.

The fracturing art is full of methods for directing the fracture. In general, a well is drilled and a pipe or tube set. This tube is then notched in the direction it is desired for the fracture to proceed. In general, this notch will be at the interface between the salt layer and the overburden or at the bottom of the salt bed. This is a matter of choice and will depend generally upon the mining technique to be later employed, the solvent, the salt, etc. as is known to the art. The fracture can also be initiated within the salt bed itself, however, the fracture in this case will generally trend upward to the interface and then proceed along the interface between salt and overburden. If, on the other hand, the bed is of suitable formation, the fracture can proceed essentially horizontal.

The spacing of the well from the cavern can vary over a wide range, e.g., almost adjacent the cavern to up to about 1500 ft. However, as a practical matter, spacing of less than about 50 feet would generally accomplish little while the more remote the spacing, the greater the danger of missing the cavern. Therefore, the general spacing will be between 50 feet and 500 feet. As is well known in the art, many factors affect the direction of a fracture. However, even with all the geological features favorable to fracturing in the desired direction, it has been found that the direction of fracture is diverted and will seldom, if ever, enter an unpressurized cavern. For this reason we prefer to space our fracturing well within the distance of 50 to 250 feet. With such spacing generally we are successful 99+ percent, whereas in the absence of our method the results are almost negative. The location of the fracturing well will, of course, depend on the lateral direction in which it is desired to grow the cavern. While the older injection well can continue to be used, it will be preferable to utilize the new well, or fracturing well, as the injection well after the fracture is made, to assure the lean solvent coming in contact with the salt prior to dilution in the cavern. It is well known in the art that many fluids can be used to fracture, generally we will use water or brine with suitable propping agents, bactericides, etc. as the particular circumstance requires.

After the cavern is pressurized to at least the overburden pressure, generally about 10% excess, fracturing fluid is forced down the fracturing well under sufficient head to breakdown the formation and cause the fracture to extend until the fluid enters the cavern. A further increase in the observed cavern pressure indicates successful entry of the cavern. Pressure should be relieved by the removal of fluid only to maintain the original static cavern pressure until satisfactory communication between the well and the cavern along the fracture is assured. Fracturing fluid is followed by a suitable solvent to obtain communication prior to relieving pressure.

The invention will be further described in conjunction with the attached drawing which is a schematic showing of a cavern and well in a salt formation.

Referring now to the drawing, the cavern 1 in salt bed 3 has been extended to a size where the recovery of salt has been materially reduced due to cavern size. The injection pipe 7 which extends from the cavern to surface 6 has been capped via cap 15. The solution recovery well 8 is equipped with a suitable pump and brine source 16. This recovery well also extends from the surface 6 to near the bottom of the cavern. A third well 11 is drilled a predetermined distance from the cavern 1 in the direction

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it is desired to cause the cavern to grow. The concrete 19 used for cementing the pipe in place is allowed to stand in the pipe to about the height of the notch. As shown, well 11 is set to below the salt bed and is notched at 10 near the bottom of the salt bed. At the surface, well 11 is supplied with a fracturing pump 12 and a fracturing liquid, such as brine, supply 13. The salt bed 3 lies between the overburden 9 with an interface 4 and subsoil 17 with interface 20. In the example, the cavern is 800 feet beneath surface 6. About 425 pounds pressure is maintained on cavern 1 via pressure means 16. Then the fracturing pressure is applied to well 11 via pump 12 causing a fracture 14 to start in the direction of the cavern 2. As illustrated, the fracture remains horizontal. However, a vertical fracture is equally effective. After the fracture is completed, the fracturing equipment is removed as is the pressure means 16 thus allowing the pressure in the cavern to be lowered to the normal hydrostatic pressure. Fresh solvent, water, is then pumped into well 11 dissolving salt from bed 3, and solution is recovered via conduit or pipe 8. When this new cavity has been sufficiently enlarged, the procedure is repeated.

When the test is repeated via a new well spaced from the cavern, but without first pressuring cavern 1, the fracture starts in the desired direction, but forms an elliptical fracture away from the cavern.

As illustrated, both the cavern and fracturing fluid were pressured with brine. However, any fluid would be suitable for these purposes, e.g. a gas such as air could have been used in cavern 1, and plain water could have been utilized as the fracturing liquid. It should also be understood that propping agents such as sand could be

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used in the fracturing fluid as well as other fracturing aids.

We claim:

1. A method of fracturing into a preformed underground cavity which comprises pressuring said cavity to a pressure to relieve the side wall pressure of said cavity, maintaining said pressure below the fracturing pressure from said cavity, at least equal to the overhead hydrostatic pressure, drilling a fracturing well a predetermined distance from said cavity, and fracturing from said well in the direction of said cavity while maintaining the aforesaid pressure in said cavity.

2. A method of extending a cavity formed underground in a salt formation, said salt formation lying between two insoluble layers, said method comprising preparing a fracturing well a predetermined distance and direction from said cavity, pressuring said cavity to at least the pressure of the hydrostatic head equal to the depth of said cavity below the earth's surface and less than that pressure which would initiate fracture from said cavity, and thereafter initiating a fracture from said fracturing well in the direction of said cavity, and continuing the fracturing procedure into said well until the initiated fracture enters said cavity.

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