

Feb. 27, 1968

C. F. KNUTSON ETAL

3,370,887

HOLE PREPARATION FOR FRACTURING SOLUTION MINING WELLS

Filed April 5, 1966

2 Sheets-Sheet 1

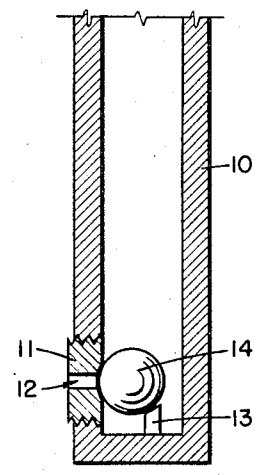


FIG. 2

X 103

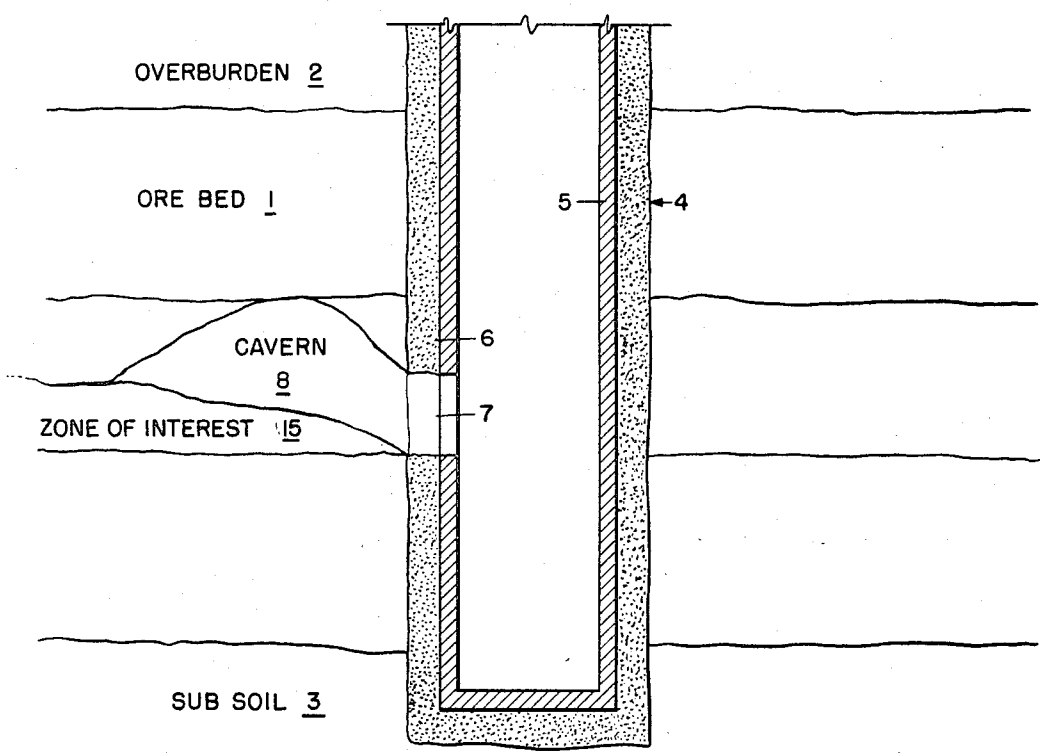


FIG. 1

INVENTOR.
CARROLL F. KNUTSON
BRUCE G. BRAY
HARRY A. WAHL, JR.

BY *Robert B. Cleary*
ATTORNEY

Feb. 27, 1968

C. F. KNUTSON ETAL

3,370,887

HOLE PREPARATION FOR FRACTURING SOLUTION MINING WELLS

Filed April 5, 1966

2 Sheets-Sheet 2

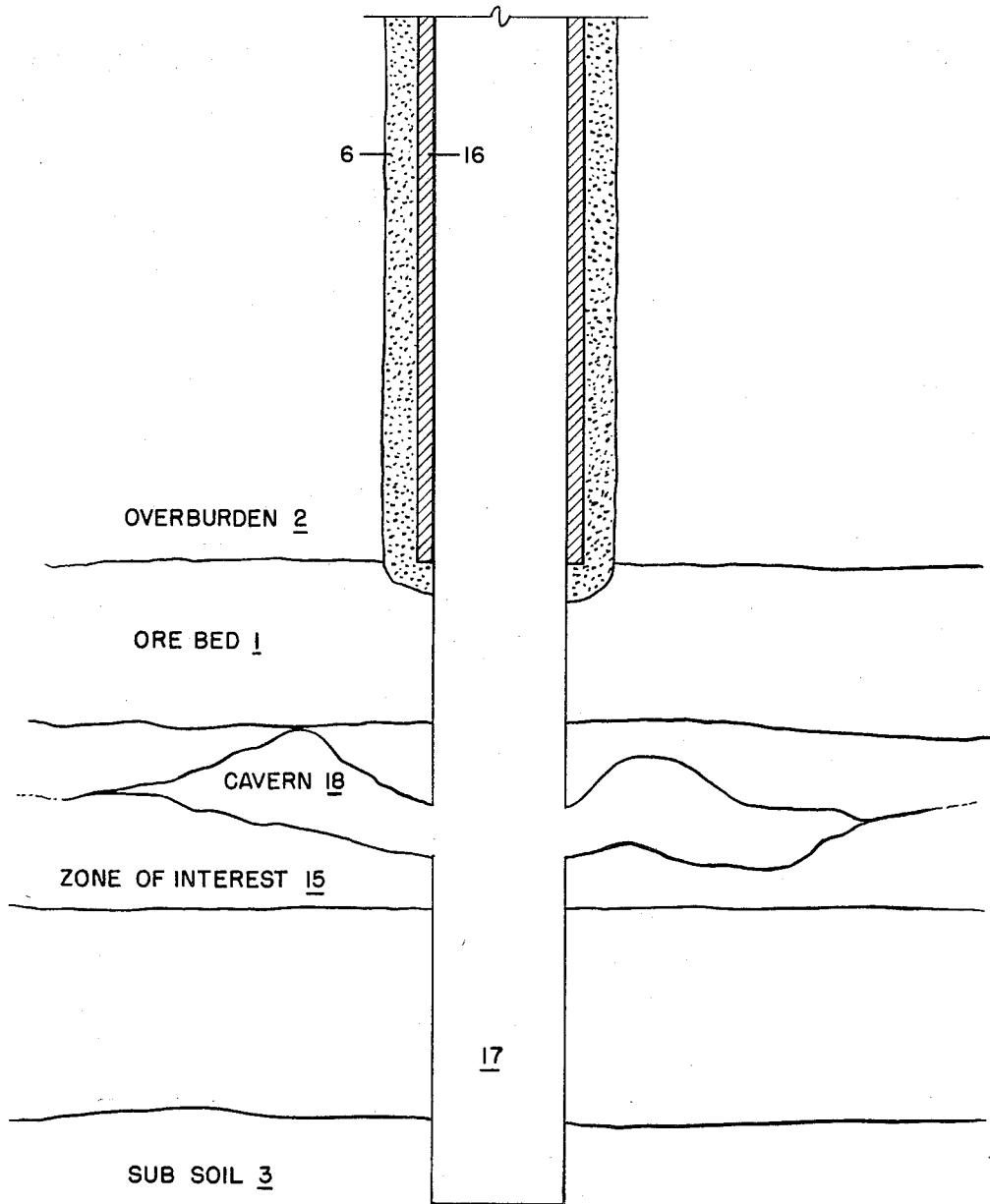


FIG. 3

INVENTORS
CARROLL F. KNUTSON
BRUCE G. BRAY
HARRY A. WAHL, JR.

BY *Robert H. Cole*
ATTORNEY

1

3,370,887

**HOLE PREPARATION FOR FRACTURING
SOLUTION MINING WELLS**

Carroll F. Knutson, Bruce G. Bray and Harry A. Wahl, Jr., Ponca City, Okla., assignors to Continental Oil Company, Ponca City, Okla., a corporation of Delaware

Filed Apr. 5, 1966, Ser. No. 540,234

10 Claims. (Cl. 299-4)

This invention relates broadly to solution mining. In one aspect, this invention relates to a novel method of initiating fracture in a mixed salt bed in the area concentrated in the desired salt. In another aspect, this invention relates to a novel notching tool.

In recent years, solution mining of soluble salts and ores has become widespread. Such salts as potassium chloride, trona, potassium sulfate and the like can be recovered by circulating water through a subterranean deposit of such salts. Sulfur is recovered by introducing steam and water to melt the sulfur and the molten sulfur pumped to the surface. However, many of these deposits are more often than not associated with other salts which it is not desirable to recover, especially sodium chloride. Therefore, saturated brine is frequently employed as the solvent, the brine dissolves the desired salt which can be recovered by suitable methods and the brine recirculated. Frequently, the strata salt is comparatively thin and for effective recovery, hydrofracturing is frequently employed. Fracturing between wells is often employed in order to optimize the exposed surface to solvent. It has been proposed to fracture at interface between salts and protect either the roof or floor of the cavern by use of inertis which are nonmiscible with the solvent. However, this has the disadvantage of cutting off solvent contact with desirable salts when the fracture deviates from the desired position.

It is also difficult to initiate the fracture at the optimum level with respect to the desired salt since all of this is performed many feet below the earth's surface.

In preparing the bed for fracturing, typically a well is drilled into or through the salt bed and a casing is cemented in place. A notching tool, typically a tube with an orifice lined with an abrasive-resistant liner is set in the tube, and the bottom of the tube is sealed. The notching tube is lowered in the casing to the desired level and the orifice oriented in the direction to be notched. A highly abrasive fluid, such as sand-laden water, is forced through the nozzle at high velocity, preferably while the tube is being reciprocated vertically and rotated. The high velocity abrasive fluid then cuts a notch into the salt bed. After the notch is formed, the top of the tube is capped or sealed and sufficient pressure is applied until the fracture is initiated. This is determined by a sudden drop in pressure and usually requires a surface pressure in pounds per square inch equal to about one-half of the depth of the hole in feet. Thus, to fracture 800 feet below the earth's surface about 400 p.s.i. pressure is required.

After the fracture has been initiated, it is often desirable to utilize the notching tube to introduce solvent into the hole. However, since the notching orifice is necessarily small in diameter, it is necessary to pull the tubing and enlarge the hole in the notching tubing. This involves considerable time and labor.

It is an object of this invention to provide a method to initiate a fracture in a salt bed comprising both a desired salt and an undesired salt in that portion of the bed having a high concentration of the desired salt.

It is another object of this invention to provide a novel method of notching and fracturing a salt bed.

It is still another object of this invention to provide a novel notching tool.

2

In one aspect, this invention comprises contacting a salt bed with a nonsolvent with respect to an undesired salt and solvent with respect to the desired salt, thereby creating a small cavity in said salt bed at the zone of highest concentration of desired salt, and thereafter initiating a fracture by application of hydraulic pressure.

In another aspect, this invention comprises utilizing a solvent saturated with respect to an undesired salt in subterranean salt bed and undersaturated with respect to a desired salt in said salt bed as the carrier fluid for a notching composition, notching said salt bed with said fluid using a notching tool having an orifice under a pressure differential across the notching orifice below a predetermined maximum until a small cavern is formed in said salt bed, increasing the differential pressure above said predetermined maximum to blow said orifice out of the notching tool, thereby increasing the orifice size and thereafter fracturing said salt bed by hydraulic pressure applied to the said solvent.

In a third aspect, this invention comprises a notching tool containing an orifice member in a tube so that said notching orifice member remains in place below a certain predetermined pressure and said member is forced out of said tube when said pressure is exceeded.

As has been said, this invention is particularly applicable to recovery of a desired salt such as potassium chloride, trona, potassium sulfate and the like in admixture with an undesired salt such as sodium chloride. However, the apparatus of this invention has use in solution mining generally, such as mining of sulfur or salts.

The invention will be described in more detail with reference to recovery of KCl from KCl-NaCl deposits. It is known that NaCl solubility in water is only partially affected by temperature, whereas KCl is much more soluble in hot water than in cool water. Therefore, by circulating a saturated hot NaCl solution into a mixed salt bed, the brine will pick up KCl. The brine is taken to the surface, cooled (causing KCl to precipitate), reheated and circulated back to the bed. This process is known and is not a part of this invention.

It is also known to notch a casing preparatory to hydrofracturing, utilizing an abrasive fluid composition. The notching orifice can be case hardened, lined with an abrasive resistive liner or as an alternative a mechanical notch can be used. All of these are well known to the art and need no elaboration here.

The invention will best be understood by referring to the figures of which:

FIGURE 1 shows a notched casing and initial cavern in a salt bed,

FIGURE 2 shows a notching tube with the orifice in place and means for blowing the notch out of the tube, and

FIGURE 3 shows a notching tube arranged for notching directly into the ore bed.

Referring to FIGURE 1, salt bed 1 lying between overburden 2 and underlying strata 3 is drilled, forming well 4. Casing 5 is set and cemented in place with cement 6. The casing is notched, preferably as hereinafter described, and hot saturated sodium chloride is passed through notch 7 where it contacts the salt bed consisting of NaCl and KCl. The KCl (zone 15) is concentrated, in this case, slightly above the position of the notch. The hot brine picks up KCl and is pumped back to the surface by any convenient method. As the KCl is dissolved, the cavern 8 is formed along the level of greatest KCl concentration. Usually a cavern of 2 to 10 cubic feet will suffice. At this point, the top of the casing 5 is capped and pressure applied until fracture is initiated along fracture line 9. As has been indicated, when the fracture is initiated, a sudden drop in pressure will be noted, and the applied pressure is removed. Preferably, a second well will be drilled

3

into the salt bed to intersect the fracture, and hot brine will circulate from the first well, dissolving KCl, and be removed from the second well. However, it is within the scope of the invention to insert a second tube or utilize the notching tube in the casing 5 and withdraw solution from the bottom of the input well or at a second notched position. Such solution mining methods are well known to the art.

Referring to FIGURE 2, a heavy tube 10 has a notching member 11 containing orifice 12 inserted into its wall so as to stay in place below a predetermined pressure. This notching member can be driven in place, threaded, welded, etc. The nature of the metal, frictional coefficients, tensile strengths, etc. will determine the exact design to obtain the desired blow out pressure. Such pressure blow out plugs are well known in the art of pressure vessels, and it is within the skill of the art to design the plug for a desired blow out pressure. The orifice 12 must be abrasive resistant as previously mentioned. Preferably, the surface of the nozzle 11 inside the casing will be slightly concave for reasons which will become obvious later.

In operation, the assembled tube 10 is lowered into casing 5 and the nozzle oriented in the desired direction. Saturated brine containing abrasive particles such as silica sand is pumped into the tube 10 say at 3000 p.s.i.g. The tube is reciprocated across the area 7 of casing 5 until a notch has been opened and cavern 8 is partially opened. At this time, the pressure increased to the pressure wherein the number 11 will blow, say 4000 p.s.i.g. This can be conveniently done by dropping a steel ball 14 down the tube 10. The flowing fluid will cause the ball to seat against the opening of the nozzle which is slightly concave and allow build up of pressure. The ball can rest on the bottom of the tube 11 or a support 13 can be supplied for supporting the ball at the proper level. The steel ball will have a diameter slightly less than that of the nozzle so that when the pressure build up causes the nozzle to blow, the ball will follow and the entire assembly (nozzle and ball) will be blown through notch 7 in casing 5 and into cavern 8. The tube 10 can then be lowered to the bottom of casing 5 and a bottom hole pump placed therein. Fresh solvent would then be passed down the annulus between tube 10 and casing 5 and passed into the cavern via notch 7. When the cavern solvent has dissolved the KCl, the flow will be reversed and saturated brine will pass back through notch 7 and the opening made by blowing the nozzle and will be pumped to the surface to recover KCl. Alternatively, a second notch can be put in casing 5 prior to blowing the nozzle and a packing ring set between the two notches. In this manner, the solvent flow will be continuous. In still another method of operation particularly applicable to dual well mining, the notch 7 would be cut vertically over a large surface of the salt bed. The tube 10, with nozzle blown, would be reciprocated vertically across this face, thus providing for a large opening to the cavern.

Referring to FIGURE 3, a casing 16 is set either in an anhydrite stratum or in the salt bed and cemented in place by cement 6. The hole 17 is then drilled through the zone of interest 15 and the notching tool of FIGURE 2 is lowered into well 17 to the zone of interest 15. The tool is slowly rotated and vertically reciprocated, forming a cavern 18 around the well 17. After the cavern is formed, the plug 11 is blown as previously described and the formation fractured radially in the zone of interest.

The advantage of preparing a cavern by the method of this invention prior to fracturing is two-fold. First, the cavern will initiate the fracture where the desired salt is at its highest concentration. Secondly, the cavern provides a large surface area for application of pressure, thus facilitating fracturing.

4

The invention thus described, we claim:

1. In fracturing a salt bed with hydraulic pressure comprising a mixture of salts wherein at least one of the salts is to be recovered and at least one salt is not desired, the improvement comprising contacting said salt bed with a liquid solvent for the desired salts and nonsolvent for the undesired salts to form an initial cavity in the salt bed and thereafter applying sufficient pressure to said cavity to fracture said salt bed.

2. The improvement of claim 1 wherein said solvent is water saturated with respect to the undesired salts and undersaturated with respect to the desired salts.

3. The improvement of claim 2 wherein the desired salt is potassium chloride and the undesired salt is sodium chloride.

4. In hydrofracturing a salt bed and recovering soluble salt from said bed by drilling a well into said salt bed, introducing hydrostatic pressure into said salt bed through said well and thereafter utilizing said well in passing solvent through the resulting fracture, the improvement comprising first notching said salt bed by passing a notching fluid at high velocity through an orifice member set in the side of a tube in said well at the level of desired notching thereby forming a notched cavity, said orifice member being set by means which will release said nozzle member from said tube at a predetermined pressure, thereafter increasing the differential pressure across said nozzle member to said predetermined pressure thus forcing said member from said tube and thereafter applying sufficient pressure to the said notched cavity to fracture said salt bed.

5. The improvement of claim 4 wherein said salt bed comprises a desired salt and an undesirable salt.

6. The improvement of claim 5 wherein said notching fluid is saturated with respect to the undesired salts and is undersaturated with respect to the salt desired to be recovered.

7. The improvement of claim 6 wherein said fracturing is from said well bore to a second well bore and subsequent to fracturing and forcing said nozzle member from said tube, a solvent for the salt to be recovered is introduced through said tube and the opening therein resulting from forcing said nozzle member out and solvent having salt dissolved therein is recovered from said second well bore.

8. A tool for notching within a well bore comprising in combination an elongated tube, an orifice member inserted into the wall of said tube in such a manner that said orifice member will be expelled from the walls of said tube when the pressure across said member exceeds a predetermined maximum, said orifice member having a bore therethrough and the outer periphery of said orifice is substantially greater than the diameter of said orifice member bore.

9. The tool of claim 8 wherein said outer periphery is of approximately the same cross sectional area as the cross sectional area of said tube.

10. The tool of claim 9 wherein said tube contains means for closing the bore through said orifice member

References Cited

UNITED STATES PATENTS

2,758,653	8/1956	Desbrow	166-42 X
2,825,412	3/1958	Standridge	166-224 X
2,838,117	6/1958	Clark et al.	166-42
2,850,270	9/1958	Hanson	299-4
3,130,786	4/1964	Brown et al.	166-42 X

ERNEST R. PURSER, *Primary Examiner*.