United States Patent

Jacoby

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[54] **GROUTING FISSURES IN UNDERGROUND ROCK SALT DEPOSITS**

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[52] **U.S. Cl.** **61/35,** 166/288, 175/72, 299/5

[51] **Int. Cl.** **E02d 19/16**

[58] **Field of Search** .....61/35, 36, .5; 166/285, 288, 166/292; 175/72; 299/5

[56] **References Cited**

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[57] **ABSTRACT**

There is disclosed an improved method for grouting (sealing) a ground water conducting fault zone, fissure, or the like, such as has been inadvertently intersected when mining an underground salt deposit.

6 Claims, 3 Drawing Figures

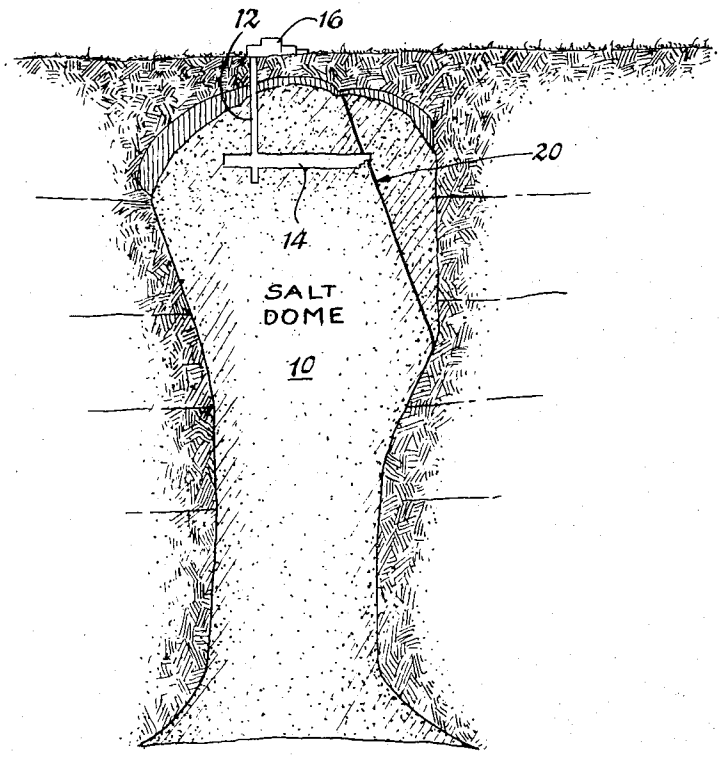


Fig. 1.

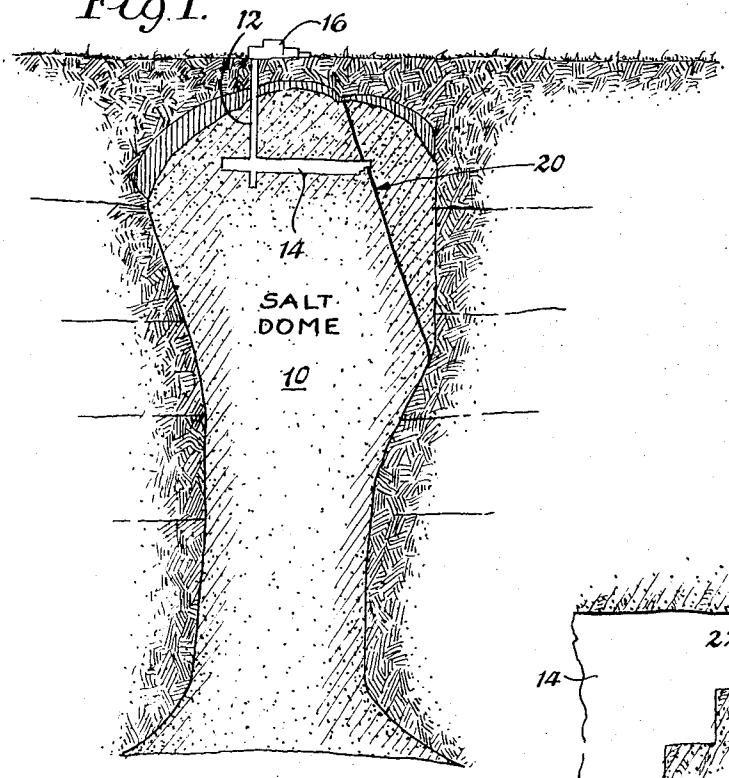


Fig. 2.

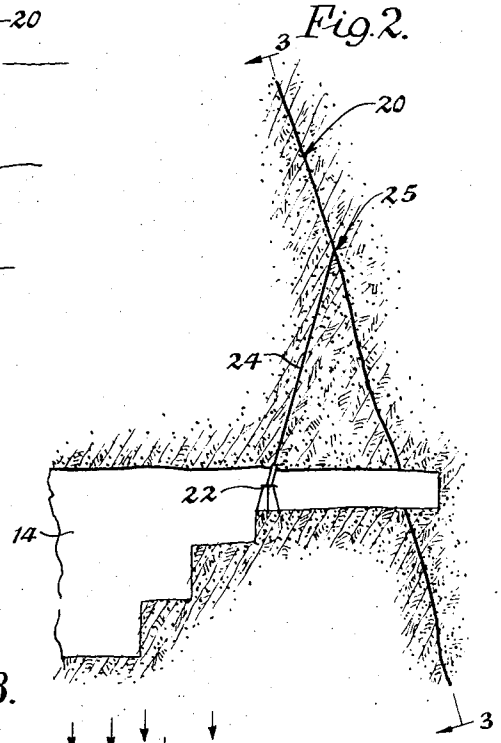
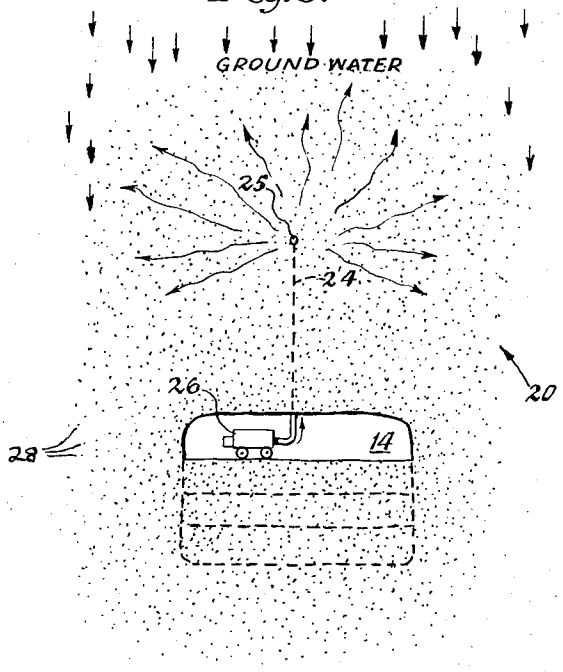


Fig. 3.



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GROUTING FISSURES IN UNDERGROUND ROCK SALT DEPOSITS

BACKGROUND AND GENERAL DESCRIPTION OF THE INVENTION

The invention relates to a method for grouting a water leaking fissure in an underground mass of sodium chloride rock salt or the like; and has particular application to the problem of closing off such fissures from within an underground mine opening.

On occasion earth movements and/or other geological pressure forces subject underground salt deposits to fracturing stresses, with the result that mine openings thereinto will on such occasions intersect fracture zones or fissures which thereupon conduct ambient ground waters into the mine workings. Conventional grouting methods are only partially effective in such cases because the fissures are often too narrow to permit introduction of conventional sealing compounds, reagents, or the like. The present invention takes advantage of the fact that air can be forced under pressure to penetrate into the tiniest of cracks or crevices, and will flow through the narrowest of interstices; and also that when air is introduced into any body of liquid it naturally rises therewithin and generates an "air-lift" effect against the liquid. The invention utilizes the fact that when ground water moves through an opening in a salt mass the water dissolves salt in the process until it becomes a 100 percent saturated brine solution at the ambient pressure/temperature conditions; and that such solutions may be triggered to convert into solid recrystallized salt simply by bubbling air through the brine solution.

By way of example, the invention is illustrated by the accompanying drawings wherein:

THE DRAWINGS

FIG. 1 is a diagrammatic geological sectional view showing a typical salt mining operation in a salt dome: and illustrating how the mine workings have inadvertently intersected a fault or fracture plane in the salt deposit such as operates as a conduit permitting ground waters to enter the mine workings;

FIG. 2 is an enlarged scale view of that portion of the mine, showing a first step in preparation for sealing off the intersected fissure from inside the mine; and

FIG. 3 is a view of the sealing or "grouting" operation, taken as suggested by line 3—3 of FIG. 2.

As illustrated at FIG. 1, a salt dome (designated 10) such as occur underground in Louisiana, Texas and Alabama is typically mined by drilling a vertical shaft 12 from the earth's surface downwardly into the deposit to the desired level, as determined by preliminary drilling surveys. A room-and-pillar mining system (or some alternative system) such as indicated at 14 is then developed to reach out horizontally from the foot of the shaft 12. The salt product is then brought to the surface to be processed, as in a surface plant illustrated at 16.

Due to earth movement forces thereon subsequent to their formation such salt domes typically develop "-spire" fractures and/or fault planes as indicated at 20 (FIGS. 1 and 2 of the drawing herewith). Whereas the salt dome per se comprises an extremely solid and water-tight mass, such fissures therein provide conduits for seepage of ground waters therethrough. Therefore,

whenever a mine working such as indicated at 14 is driven so as to intersect a fissure of this type the mine will become flooded unless adequate pumping facilities are established and maintained. Alternatively, in some instances where the fissure is of sufficient width, some conventional form of "grouting" may be employed with some degree of success, perhaps sufficient to reduce the pumping requirements to an economically feasible level. The conventional grouting methods referred to usually involve the introduction (into the fissure, either from above or below) of some form of quick setting cement, or materials compounded to react and form solids that expand. However, such prior grouting methods are usually only partially effective and are uncertain and unreliable as to permanence, and are invariably quite expensive.

When working at substantial depths underground the accompanying ground water pressure heads are enormous. Therefore, it is not only difficult to inject a grouting material into such a fissure against the ambient pressure, but in the case of a narrow fissure it is impossible to inject any solids-containing slurry, or the like. At substantial depths underground even a fissure of no measurably appreciable width for example will nevertheless leak water into the mine working, and it is physically impossible to inject a solids-containing slurry or the like into such a fissure. Furthermore, it will be appreciated that in such an instance it is impracticable to attempt to inject even a clear liquid for any substantial distances into such a fissure against the opposing hydrostatic pressure.

On the other hand, the present invention takes advantage of the fact that a gas such as air may be forced to flow into a dimensionally minute but highly pressurized fissure, because a gas will flow where a liquid cannot flow due to surface tension/friction factors. Furthermore, the invention takes advantage of the fact that whenever a gas is forced under pressure into a body of liquid of higher specific gravity, the gas automatically "bubbles" upwardly throughout the vertical extent of the body of liquid.

However, the major phenomenon upon which the present invention operates derives from the fact that whenever ground waters percolate through a readily soluble mineral, such as sodium chloride salt, a brine solution is thereby formed. When the rate of flow of solvent through the salt is sufficiently slow that no constantly enlarging channel is washed through the mineral, the brine solution is the fissure will inevitably be an approximately 100 percent saturated salt solution. This means that at the existing temperature the solution will accommodate no additional proportion of salt without undergoing recrystallization.

In accordance with the present invention, assuming that the encountered fissure is not of the type such as may be blocked off and grouted by conventional methods, the exit of the fissure seam will first be carefully surveyed with a view to determining the parameters of its plane. A rock drill 22 or the like will then be set up in place as shown at FIG. 2 so as to direct a drill hole 24 through a substantial body of solid salt until the hole intersects the plane of the fissure 20 at a substantial distance away from the elevation above the exit of the fissure into the mine working. Intersection of the fissure by the bore hole as indicated at 25 will of course

be recognized by the fact that ground waters will now come in through the bore hole.

Any suitable means for supplying air under pressure to the bore hole **24** will now be applied such as by means of a portable air compressor unit as illustrated at **26** (FIG. 3); and the pressure thereof regulated so that air will be injected through the bore hole into the fissure at a substantial volumetric rate. The air should be dry, and preferably at an elevated temperature such as produced by an air compressor as commonly used in mine workings. The dry warm air entering the fissure absorbs moisture from the saturated salt solution in the fissure which thereupon becomes supersaturated. The process of salt recrystallization thereupon initiates, forming a curtain of descending seed crystals **28** which grow until they solidly fill that portion of the fissure which umbrellas the mine working. As the crystal growths proceed the supplied air finds its way around, through and between the growing crystals; all the while absorbing water from the solution until the fissure is sealed against descending liquid flow from above as explained hereinabove.

It is noteworthy that when the air is first pumped into the fissure it tends to bubble upwardly throughout the brine solution within the fissure. Thus, the "air-lift" principle operates to carry the drying air upwardly while at the same time fanning-out horizontally within the fissure. Thus the seed crystals of salt form throughout the fissure, providing therein a curtain-like matrix of constantly growing crystals; thereby operating eventually to seal off the fissure at a substantial elevation above and around the mine working. The "air-lift" effect operates to assist in balancing and/or overcoming the hydrostatic pressures accompanying the ambient ground waters, thereby stalling their flow progress into the workings and providing an improvement of quietude for salt recrystallization and plugging of the fissure as explained hereinabove.

Whereas the specification hereinabove refers primarily to the use of heated air as being the preferred form of gas to be employed for drying the in-flowing brine solution and precipitating salt to plug the fissure, it is to be understood that any other suitable water absorbing gas may be employed. It is also to be understood that the invention is particularly efficacious because of the fact that when the solid salt particles precipitate out of the brine solution in the fissure, they weld themselves into integrally structured relation with the rock salt walls of the fissure; whereby a unified crystalline and water impervious structure is provided having superior water sealing properties.

This sealing system is therefore far superior to conventional grouting methods involving the use of foreign filler substances which do not bond/merge with the salt walls of the fissure, and in some cases tend to shrink after setting. Also, in some cases conventional grouting substances are exothermic while setting and thereby subject the fissure walls to deleterious expansion/contraction forces.

I claim;

1. The method of reducing or preventing flow of a brine solution through a fissure in an underground rock salt deposit into a mine working intersecting said fissure, said method comprising;

injecting drying gas into said fissure at a volumetric rate sufficient to percolate through said solution while absorbing water from said solution and thereby initiating recrystallization of solid salt from said solution, and continuing such ejection until solid salt crystallizes out of said solution and salt crystals grow inside said fissure and attach to the walls thereof and to each other to provide a solid structurally integrated plug of rock salt filling said fissure ambient to said mine working.

2. The method according to claim **1** wherein said drying gas is air.

3. The method according to claim **2** wherein said air is heated.

4. The method according to claim **1** wherein injection of said drying gas into said fissure is accomplished by first drilling a bore hole through a solid rock salt boundary portion of the mine working so as to intersect said fissure at a location a substantial distance away from the mine working, and then coupling a source of pressured drying gas into said bore hole for transmission therethrough and into said fissure for dispersion in all directions within said fissure.

5. The method according to claim **4** wherein said drying gas is air.

6. The method according to claim **4** wherein said drying gas is heated air.

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