Aug. 12, 1958 M. W. PULLEN, JR 2,847,202

METHOD OF MINING SALT USING TWO WELLS CONNECTED BY FLUID FRACTURING

Filed Feb. 9, 1956 2 Sheets-Sheet 1

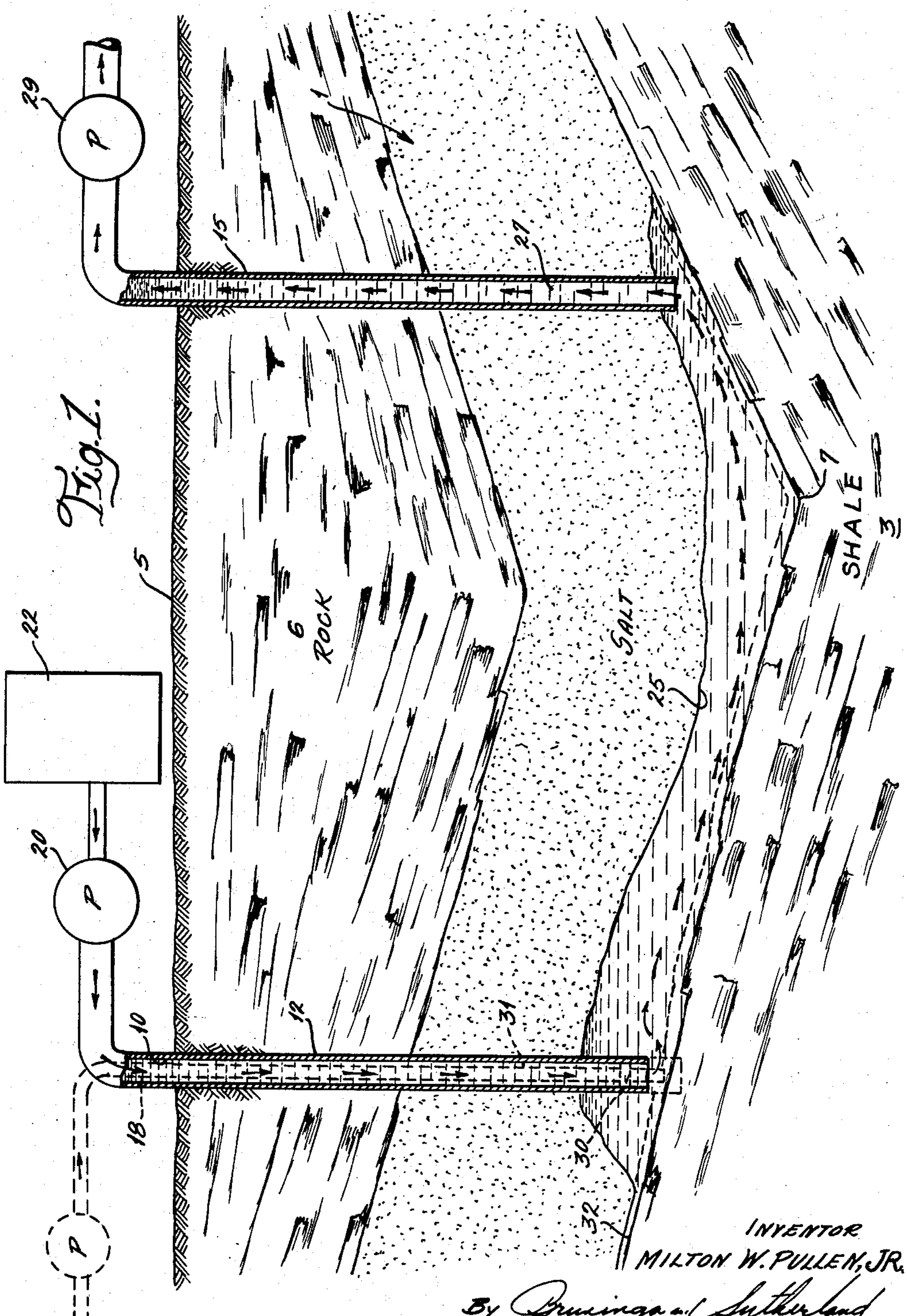


Fig. 1

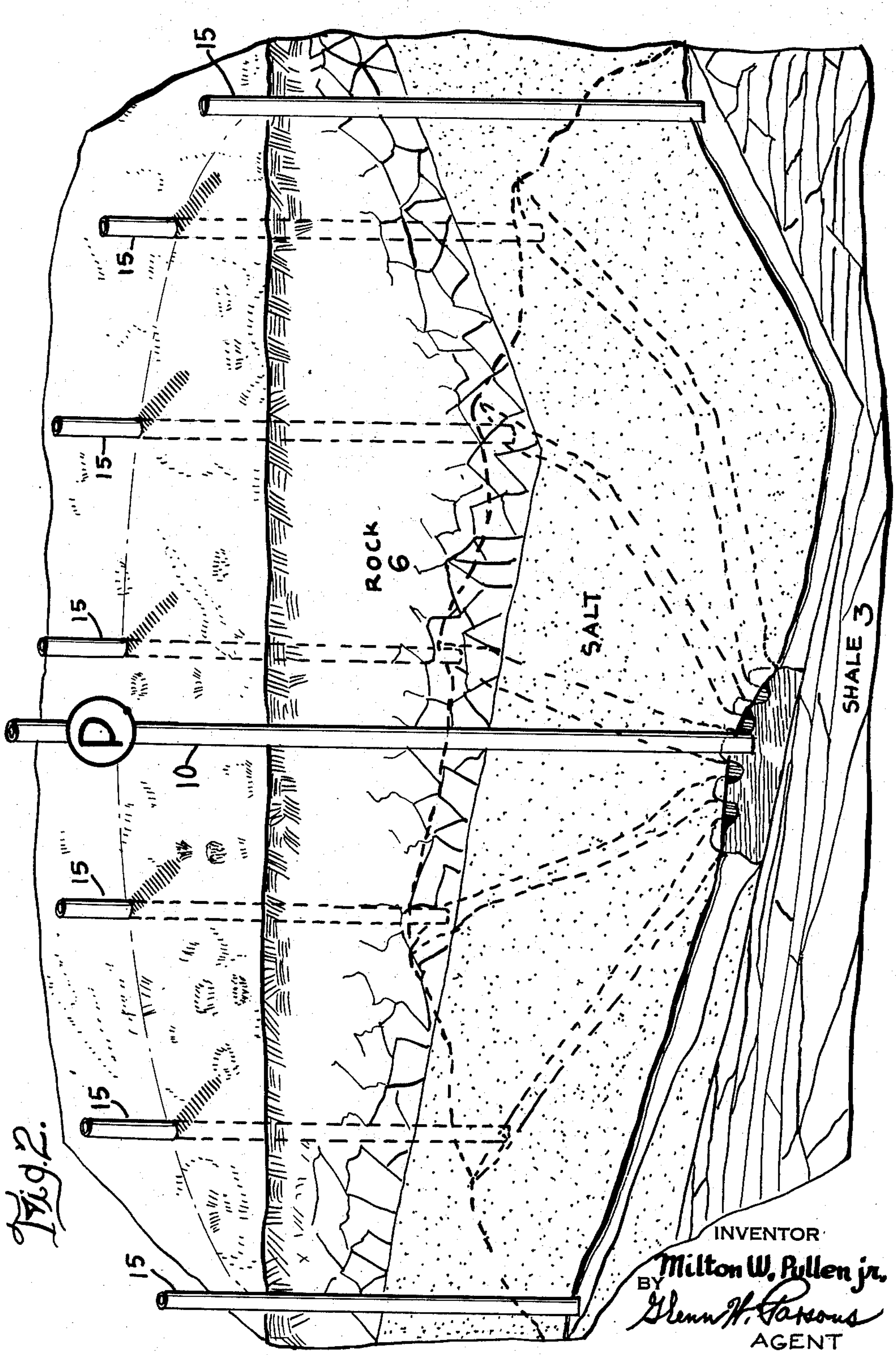
INVENTOR
MILTON W. PULLEN, JR.
By Bruininga and Sutherland
ATTORNEYS.

Aug. 12, 1958 M. W. PULLEN, JR 2,847,202

METHOD OF MINING SALT USING TWO WELLS CONNECTED BY FLUID FRACTURING

Filed Feb. 9, 1956 2 Sheets-Sheet 2

Fig. 2.



INVENTOR
Milton W. Pullen jr.
BY Glenn W. Parsons
AGENT

United States Patent Office

2,847,202

Patented Aug. 12, 1958

1

2,847,202

METHOD OF MINING SALT USING TWO WELLS CONNECTED BY FLUID FRACTURING

Milton W. Pullen, Jr., Urbana, Ill., assignor, by mesne assignments, to Food Machinery and Chemical Corporation, New York, N. Y., a corporation of Delaware

Application February 9, 1956, Serial No. 564,417

5 Claims. (Cl. 262—3)

This invention relates to the solution mining of soluble minerals of which common salt is the prime example. It is also applicable to such minerals as borax, potash and the like.

In mining soluble salt, it is common practice to drill a well into an underground layer of salt, case the well to a point near its bottom, and insert in the well bore a central pipe or tubing to the bottom of the well. Water is pumped or dumped down the central tubing, where it dissolves the salt, and the produced brine is forced upwardly, by the pressure of incoming fresh water, between the casing and the central tubing. Alternatively, the water is pumped or dumped down the casing and the brine produced upwardly through the central tubing. Either method produces a cavity in the salt which becomes inverted pear-shaped in vertical section because the heavier brine tends to stay below, while the fresh water rises to the top and dissolves more salt. This produces a rather weak structure with respect to the non-salt roof of the salt deposit, and leads to caving of the roof, clogging of the well and contaminating of the brine. Another disadvantage of such a system is that as the cavity enlarges, the flow velocity of the liquid with respect to the walls of the cavity lessens, which leads to the deposit of insoluble materials on the surface of the salt, so that further solution is inhibited. The deposit of insoluble materials is particularly marked on the bottom of the cavity, but also occurs on the sides.

The desirability of joining two or more adjacent wells through a passage in the salt, to form a gallery, so that water may be introduced into one well and brine produced from another, has been recognized. In such a situation, the velocity of the water with respect to the walls of the cavity can be maintained high, and a much greater effective surface can be developed. Stratification of the brine is also minimized. However, in wells which have heretofore been connected, the gallery has been made immediately beneath the roof of the salt deposit. This has been true because the only way of joining adjacent wells heretofore has been to produce sufficiently large cavities about the respective wells so that the cavities meet. Inasmuch as the cavities assume an inverted cone or pear shape, the joining of the cavities takes place near their tops. This arrangement aggravates the caving problem, since more of the roof is unsupported than with the cavities alone, and the roof is subjected to the scouring action of the water.

A way in which adjacent wells have been connected more or less fortuitously in the past is by sinking one well below another in an inclined stratum of salt. Because of the fact that the heavier brine remains on the lower side of the cavity while the fresh water rises to the top, the cavity follows the upward inclination of the bed so that the cavity from the lower of the two wells will eventually progress up the inclined bed to the higher of the two wells. This arrangement, although it makes the joining of the two wells more easily accomplished, is still subject to the same difficulties so far as the roof support

2

is concerned, and also as far as the deposit of insoluble materials on the surface of the salt is concerned (although this problem is much less marked in gallery-type wells than in the cavity-type). Furthermore, the arrangement is only feasible when the stratum is inclined and the wells can be properly positioned.

Where two adjacent wells happen to be on opposite slopes of a syncline, it has heretofore proved impossible to join them, since, as has been pointed out, the cavities extend upwardly along the inclined beds, hence away from one another.

One of the objects of this invention is to provide a method of joining adjacent wells by a passage along the underside of a deposit of soluble salt, in such a way that at least one gallery is produced, whereby a solvent may be introduced into one well and brine produced from a connected well.

Other objects will become apparent to those skilled in the art in the light of the following description.

In accordance with this invention, generally stated, adjacent salt wells are joined by formation fracturing a dense salt bed either along the interface between the lowermost surface of the bed of salt and an underlying non-salt stratum or along a shale or othr lithological parting or stratum in the lower part of the salt bed. The fracturing in accordance with this invention can be carried out even if the adjacent wells are situated on opposite sides of a syncline. The term "salt" is used hereinafter to include various soluble salts, such as sodium chloride, borax, potash and the like.

In the drawing,

Figure 1 is a sectional view, somewhat diagrammatic in character, showing adjacent wells connected in accordance with an illustrative embodiment of the method of this invention.

Fig. 2 illustrates an embodiment of this invention wherein a plurality of wells are drilled to communicate with the fracture from a centrally disposed well.

Referring to the drawing for an illustrative application of the method of this invention, reference numeral 1 indicates a bed of salt. The salt bed **1** illustrated, lies between a bed of shale **3** upon which it rests, and an overlying roof of rock strata **6** and intervening geologic formations to the surface of the earth **5**. The shale is shown as laid down in two strata meeting to form a syncline **7**. A well **10** extends from the surface of the earth **5** to the shale bed **3** on one side of the syncline **7**, while a second well **15** extends from the surface of the earth **5** to the bed of shale **3** on the opposite side of the syncline **7**.

The well **10** extends a short distance into the shale bed **3**. The lowermost end of the well, in the shale bed, may be plugged with cement, if desired. A casing **12** extends from the surface of the earth **5** to a point in the salt bed near the salt-shale interface. In the illustration, clear water **18** is shown as being pumped by a pump **20** from a reservoir **22** down the casing **12**. The water **18**, issuing from the casing **12**, passes along a gallery **25** between the bed of shale **3** and the bottom of the salt bed **1**. In the course of its passage through the gallery **25**, the water **18** dissolves salt from the bed **1** and thus becomes brine **27**. The brine **27** is forced up, or is pumped by a pump **29**, out of the well **15**.

In producing the gallery **25**, the well **10** is drilled from the surface of the earth **5** through the bed of salt **1** and a short distance into the bed of shale **3**. A packer **30**, shown in dotted lines, is set in the casing **12** of the well **10** a short distance above the bottom of the salt bed **1**. Fluid, under a pressure higher than the hydrostatic and geostatic head above the bottom of the salt bed or stratum above which the salt to be mined lies, is then introduced below the packer through a pipe **31**, Any suitable fluid may be used, such, for example, as water, brine, kerosene, napalm, mineral oil, or compressed air. The pressure of fluid between the packer and the bottom of the well is such that the salt bed and shale bed are fractured along their interface as indicated at **32**. Ordinarily, a pressure in pounds per square inch of about 1.8 times the depth in feet will be adequate to produce the fracture.

Unlike the fracturing produced in oil sands, which, being porous, dissipate the forces of the fluid so that the fracture may not run laterally satisfactorily, the salt, being dense and soluble, and lying in regular beds, fractures laterally in a very satisfactory manner.

While it is contemplated that the fracturing shall be accomplished from only one of the adjacent wells, it is within the contemplation of this invention to apply pressure alternately or, if necessary, simultaneously to more than one well.

When the formation has thus been fractured sufficiently to enable a solution to reach the well **15** from the well **10**, the packer **30** and pipe **31** are removed and a solvent, in this case, the water **18**, is pumped down the well **10**, through the space produced by the fracturing of the formations with respect to one another, and out through the well **15**. The fracturing is not blocked by the existence of the syncline, the line of cleavage or fracture following the interface down the one side of the syncline and up the other.

By producing the fracture, hence the connecting gallery, along the underside or lower part of the salt bed, a number of very important advantages are realized. Since the lighter fresh water tends to rise to the top, the fresh water is always in contact with the superincumbent salt. In this way, not only is solution facilitated, but there is no tendency to deposit insoluble materials on the working surface. On the contrary, the insolubles tend to settle out along the underlying rock, hence to protect the rock from the scouring and dissolving action of the water.

Another important advantage is that if any caving occurs, it will occur from the salt roof into the gallery. This, of course, will simply aid in the recovery of the salt and in no way contaminate the brine.

Figure 2 illustrates an embodiment of this invention wherein a plurality of wells are drilled to communicate with the fracture from a centrally disposed well.

It can be seen that more than one brine well **15** can be utilized, since the fracture generally extends radially from the fracturing well **10**, in every direction. Brine wells **15** can be positioned at any number of points within the compass of the fracture. Thus, for example, the well **10** may be in the center, with eight or ten brine wells **15** arranged in a circle around it.

Thus in Fig. 2 the central well from which the fracture emanates is indicated at **10** and a plurality of outlet wells **15** are indicated around the well **10** and communicating with the well **10** through the fracture at the interface of the salt bed and the underlying shale layer **3** and through galleries dissolved in the bottom of the salt bed.

Fresh water may be pumped down one or more of the wells **15**, and brine recovered from the well **10**. This will tend to equalize the size of the cavities and galleries at the wells **15** and **10**, since otherwise, the fresh water introduced at the well **10** will tend to dissolve salt more rapidly than the brine at the well **15**. Furthermore, when several wells **15** are used, the volume of liquid pumped from each of the wells **15** is only a fraction of the volume of fresh water introduced at the well **10**.

Numerous variations in the mechanics of the fracturing and the introduction and withdrawal of the solvent, within the scope of the appended claims, will occur to those skilled in the art in the light of the foregoing disclosure.

The order in which the wells are drilled, and whether

the wells **15** are drilled before or after the fracturing has been accomplished are also matters of choice, within the purview of those skilled in the art.

Having thus described the invention, what is claimed and desired to be secured by Letters Patent is:

1. The process of mining a bed soluble in a liquid, said bed lying in a dense underground formation and in a stratum immediately above a lithologic stratum insoluble in said liquid and having a clear parting line interface between said strata, comprising sinking a well into said lower stratum, casing the well to a point in the soluble bed near to but above the said parting line, applying a fluid fracturing pressure through said casing, above and below said interface to fracture the said strata substantially at their parting line interface, sinking another well substantially so said parting line interface, communicating with said fracture and providing communication between said wells substantially at said parting line interface, introducing a liquid solvent through one of said wells to the parting line interface at one place along the fracture and withdrawing the solvent through another of said wells at a point remote from the place at which the solvent is introduced but within the compass of the fracture causing the solvent to flow along the fracture and to dissolve said soluble mineral formation substantially from the bottom upwardly.

2. The method of mining a soluble dense underground salt formation lying above an insoluble formation and forming an interface therewith, substantially from the bottom upwardly, which comprises sinking a well through said soluble salt formation to be removed to the interface between said soluble formation and the underlying insoluble formation and into the insoluble formation, sinking another well at a spaced distance through said soluble formation to said interface, casing said wells to a point in the salt formation near to but above said interface, applying a fluid fracturing pressure to the formation through the casing of said well extending into the insoluble formation near to but above and below said interface to fracture the formation substantially at the said interface forming an underground passage between the fractured well and the well spaced therefrom and circulating a dissolving liquid between said wells to dissolve the soluble salt formation from the bottom upwardly between said wells.

3. The method of mining a soluble dense underground salt formation lying above an insoluble formation and forming an interface therewith, substantially from the bottom upwardly, which comprises sinking a well through said soluble salt formation and into the insoluble formation therebelow, inserting a casing in said well to a point near the bottom of the salt formation, applying a fracturing pressure, through said casing, above and below said interface to fracture the said formation substantially along said interface at the bottom of said salt formation, sinking another well at a spaced distance through said soluble formation to said interface, forming an underground passage between the fractured well and the well spaced therefrom, and circulating a dissolving liquid between said wells to dissolve the soluble salt formation from the bottom upwardly between said wells.

4. The method of mining a soluble dense underground salt formation lying above an insoluble formation and forming an interface therewith, substantially from the bottom upwardly, which comprises sinking a well through said soluble salt formation to be removed substantially to the interface between said soluble formation and into the underlying insoluble formation, sinking another well at a spaced distance through said soluble formation to said interface and into the underlying insoluble formation, casing said wells substantially to the bottom of but slightly above said salt formation, applying a fracturing pressure to the formation, through the casing of one of said wells, above and below said interface, said fracturing

pressure being applied substantially at the line of said interface, to fracture the formation substantially at the said interface, forming an underground passage between the fractured well and the well spaced therefrom, and circulating a dissolving liquid between said wells to dissolve the soluble salt formation from the bottom upwardly between said wells.

5. The process of mining an underground mineral, said mineral being removable in liquid form by the use of a removal liquid, and lying in a dense underground formation in a stratum immediately above a lithologic stratum insoluble in said removal liquid, and having a clear parting line interface between said strata, comprising sinking a well into said lower stratum, casing the well to a point in the removable mineral stratum near to but above said parting line, applying a fluid fracturing pressure to said formation through said casing above and below said interface to fracture the said strata substantially at their parting line interface, sinking another well substantially to said parting line interface, communicating with said fracture and providing communication between said wells through said fracture substantially at said parting line interface, introducing a removal liquid through one of said wells to the parting line interface at one place along the fracture and withdrawing the said mineral in liquid form through another of said wells at a point remote from the place at which the removal liquid is introduced but within the compass of the fracture, causing the removal liquid to flow along said fracture to remove said mineral from the formation substantially from the bottom upwardly.

References Cited in the file of this patent

UNITED STATES PATENTS

1,960,932	Tracy	May 29, 1934
2,584,605	Merriam et al.	Feb. 5, 1952
2,695,163	Pearce et al.	Nov. 23, 1954
2,712,355	Hoff	June 5, 1955
2,796,129	Brandon	June 18, 1957