July 30, 1935. E. N. TRUMP 2,009,535

METHOD AND MEANS FOR MINING A SOLUBLE

Filed June 5, 1934 2 Sheets-Sheet 1

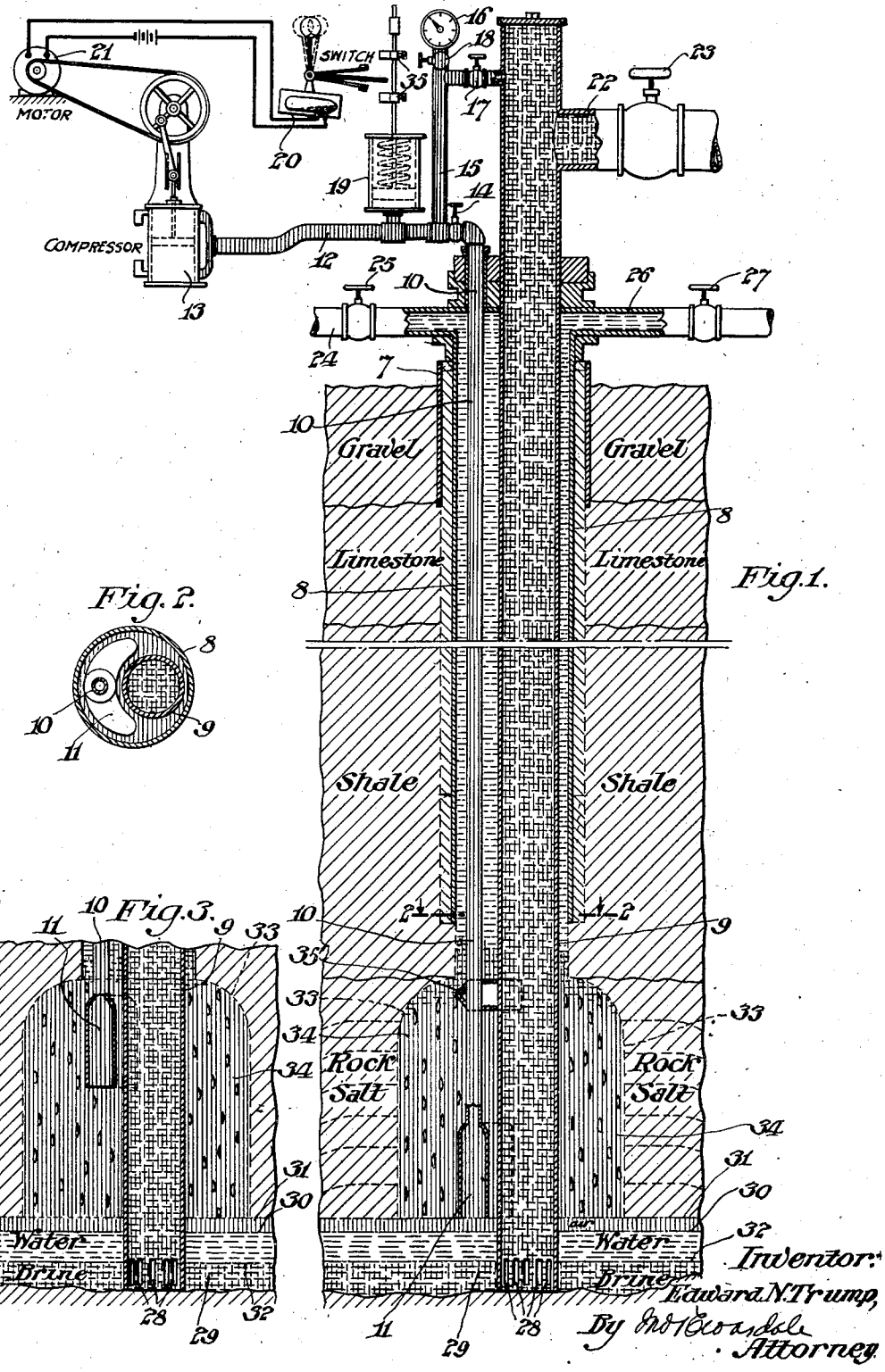


Fig. 1.

Fig. 2.

Fig. 3.

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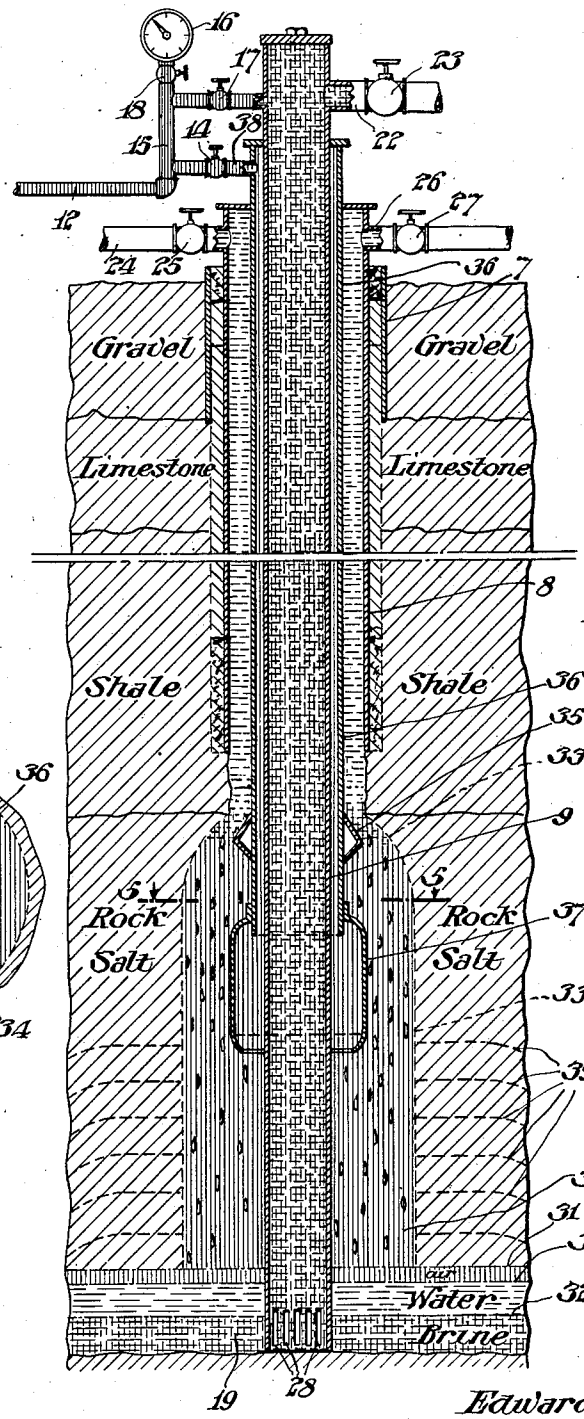


Fig. 4.

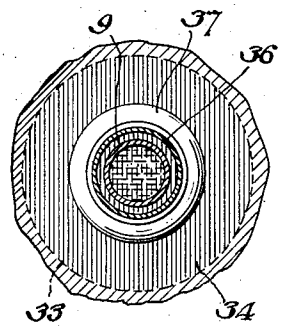


Fig. 5.

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Patented July 30, 1935 2,009,535

UNITED STATES PATENT OFFICE

2,009,535

METHOD AND MEANS FOR MINING A SOLUBLE

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Application June 5, 1934, Serial No. 729,067

4 Claims. (Cl. 262—3)

My invention relates to improvements in method and means for mining a soluble such as salt. The invention relates to that class of mining in which a solvent, such as water, is introduced into a well drilled into a bed of soluble and the resulting solution is discharged therefrom, and in which a non-solvent, such as air, is also introduced into the mine cavity to form a protecting layer between the solvent and the roof of the cavity.

The present invention is directed especially to the improved method and means for introducing and controlling the said non-solvent, so as to control as required the level of the solvent, and whereby the means employed are greatly simplified and the efficiency increased.

The invention comprises the improved method and means whereby a definite and adjustable range of pressures of the introduced non-solvent is utilized for determining the body or volume of non-solvent in the cavity, for controlling the upward dissolving movement or action of the solvent in the same.

To this end, the invention comprises—the introduction of a solvent into a cavity made in the soluble; the discharge from the cavity of the resulting solution; the introduction of non-solvent into the cavity in volume sufficient to form a substantial separating and protecting layer between the solvent and the roof of the soluble above it; the volume of non-solvent being sufficient to maintain such separation of the solvent from the soluble above it for an approximately predetermined period of time; the introduction of addition non-solvent prior to the complete absorption of the previously introduced non-solvent; utilizing the reduced pressure of the non-solvent in the cavity, prior to its complete absorption, for automatically causing the introduction of addition non-solvent, and utilizing a predetermined maximum pressure of non-solvent for interrupting said introduction.

The range of said pressures, from minimum to maximum, is such as to maintain the required bulk or volume of non-solvent, to control the level of the solvent in the cavity, and such range is adjustable, periodically to secure step by step upward dissolving from below.

Referring to the drawings, which illustrate merely by way of example, suitable means for effecting the invention;—

Fig. 1 is an elevation, partly in section, showing a preferred embodiment.

Fig. 2 is a horizontal section on line 2, 2 of Fig. 1. In this view the deflector 35' is omitted in order to show the bell 11 in plan.

Fig. 3 is a fragmentary view of the lower part of Fig. 1, showing the bell 11 in a different position.

Fig. 4 is an elevation partly in section showing a modification.

Fig. 5 is a horizontal section on line 5, 5 of Fig. 4.

Similar numerals refer to similar parts throughout the several views.

While in the drawings the relative diameters of the pipes and casings are indicated, it is obviously impossible to indicate their respective lengths relatively to such diameters. In the present example, it may be understood that the normal depth of the well is about 1500 feet, and the depth of the bed of rock salt is about 100 feet. The compressor and also the automatic control are also not to scale.

In the arrangement shown in Fig. 1, 7 indicates a 10 inch drive pipe. The 8 inch casing 8 extends downwardly within the drive pipe, and may terminate at any point in the well below any water to be cased off. The four inch brine pipe 9 extends downwardly from the top of the well, through the casing 8 to the bottom of the well. A one inch air pipe 10 extends downwardly from the top of the well, through the casing 8 and terminates in the bell 11. The bell 11 is shown in Fig. 1 and Fig. 2 as crescent shape, and partly surrounds the brine pipe 9, and has its lower margin at about the level of the desired undercut. This bell may however be positioned at a considerable distance above the undercut, as shown in Fig. 3.

The air pipe 10 is connected at the top to pipe 12, leading from air compressor 13. Pipe 12 is controlled by valve 14. Pipe 12 is also connected to a branch pipe 15 leading to brine tube 9 and also to gage 16. Valve 17 is provided between branch 15 and pipe 9, and valve 18 is provided between branch 15 and gage 16. A pressure cylinder 19 is connected to pipe 12 having therein a piston for actuating the mercury switch 20, which, in the usual way controls the circuit of motor 21, which drives the compressor 13. The brine pipe 9 is provided near its upper end with a discharge pipe 22, also provided with a suitable controlling valve 23. The casing 8 is provided near its upper end with a water inlet pipe 24 controlled by valve 25, and a discharge pipe 26 controlled by valve 27. The brine pipe 9 is provided at its lower end with a number of inlet ports 28 for the passage of brine or solution from near the

bottom of the mine cavity 29, to the brine pipe.

The top level of the water is indicated by the broken line 30, and the top level of the air by the broken line 31, so that the protecting layer or blanket of air or non-solvent occupies the space between the broken lines 30 and 31, during undercutting. The broken line 32 indicates approximately the top level of the brine. The broken lines 33 are intended to indicate the approximate shape of the cavity forming around the lower end of the brine pipe 9 by the action of the water which descends around the brine pipe and which falls, like rain, through the air which is delivered beneath the bell 11 and rises to fill said space 34 within the lines 33.

In this Fig. 1 is shown diagrammatically, a motor driven air pump or compressor 13, in association with which is arranged an automatic pressure actuated switch 20 for making and breaking the circuit of the motor. This device is adjustable, as for example, by moving the elements 35, so that predetermined maximum and minimum pressures are established, and whereby the circuit of the motor is closed upon the occurrence of minimum pressure and opened upon the occurrence of maximum pressure. By any such conventional means, well known in the art, the pressure of non-solvent in the cavity may be automatically maintained between said maximum and minimum. The adjustment of the regulator may be such as to require the operation of the pump or compressor at periods for example, of twelve or twenty-four hours.

In operation:—In accordance with the arrangement shown in Fig. 1, the well will be started with solvent, such as water, in the casing 8, and solution, such as brine, discharging from brine tube 9, with valve 25 closed and the valve 27 open, but with the space between 8 and 9 full of solvent. The valve 23 on brine tube outlet 22 is then closed, and the valve 17 on air pipe branch 15 opened, whereupon a non-solvent, such as air under pressure is forced into brine pipe 9, and gradually increases in pressure until air bubbles out of the bottom of pipe 9, and the pressure of the air, which then fills pipe 9, then becomes constant. This pressure is noted or recorded on a suitable gage, such as 16. The valve 17 on air pipe branch 15 is then closed, and the valve 14 on the air line 12 is opened, whereupon compressed air is introduced through 1'' air pipe 10, until the pressure of the air rises to two and a half pounds less than the pressure first recorded, as above stated. The supply of air is continued for a time until the pressure starts to rise, it is then interrupted. The water valve 27 is then closed, and the water valve 25 is opened, and the valve 23 on brine discharge pipe 22 is opened gradually until normal flow is resumed. The pumping of air into pipe 10 is not intended to determine the difference in pressure, but only to pump enough air into the cavity to give the difference in pressure desired. This method will supply an air cushion at the level of five feet from the bottom of the salt bed. The introduction of compressed air will have to be repeated as soon as the pressure in the cavity decreases to a predetermined minimum.

This procedure eliminates any question of friction in the piping.

The volume of air which must be pumped into the cavity should equal the volume absorbed by the solution which is forced out of the cavity. This volume is calculated upon the pressure in the cavity. Enough air should be introduced at one time to increase the thickness of the air cushion sufficiently to compensate for the amount absorbed between the intervals of intermittent introduction. It will have to be supplied more frequently at first because the weak brine will contain more air than strong brine, and the intervals may be increased as the brine is more saturated with salt, as saturated brine will not absorb more than one-third as much air as water. The amount of air required to compensate for the amount absorbed, will depend on the degree of saturation and the volume of brine forced out of the well.

If the well is, for example, to produce 200 gallons per minute with a four inch brine tube, which will equal 27 cu. ft. of brine, the amount of air required for saturated brine will be 4 cu. ft. per minute, or 5760 cu. ft. once a day. If the solution is half saturated, which is the best condition during the period of undercutting, it would require 6 cu. ft. per minute or 8600 cu. ft. once a day.

As the water descends in casing 8, that is, between casing 8 and tube 9,—and passes below the lower end of casing 8, it first comes in contact with the wall of the well, and, when it reaches the wall of the rock salt, the water will dissolve away a portion of the rock salt, so that the space 34 is formed around the bell, and the top of this space assumes a dome-shape. This dissolving action of the water upon the surrounding wall of rock salt will depend upon the momentum of the water and the deflection of the water by the bell 11, or by a special deflector, such as 35'. By adjusting the position of the bell or deflector, this dissolving action can be modified. The air, discharging beneath the bottom of the bell, rises in the dome-shaped cavity 34, and the water coming down within the casing 8, falls as rain through the air.

The dilution of the strong brine at the bottom of the cavity will be prevented if the solvent is not allowed to plunge directly downward into the shallow layer of solvent and mix with the strong solution below. If it is undisturbed, the lighter solvent will float on the heavier solution; that is, provided the downward flow of the solvent from above is checked by a suitable deflector.

The bell 11, with its inclined top wall may be used as such deflector, when positioned near the discharge end of the annular space, as in Fig. 3, or a special deflector may be used, such as 35' adjustably supported on the pipe 10, as in Fig. 1, or on pipe 9, as in Fig. 4. The deflector may be formed in any suitable way, with its upper wall inclined to break the downward flow of the solvent and deflect the same toward the outer wall of the surrounding cavity. This outward deflection of the water descending through the annular space causes the dissolving of the surrounding salt and the formation of cavity 34 with the dome-shaped roof. The deflector also serves to restrict or throttle the passage between the annular space and the cavity 34, as and for the purpose herein described.

When a well is put into operation, the water, entering through pipe 24, will pass down the annular space, between brine pipe 9 and the surrounding pipe 8, until the well is full. The weight and pressure of the water will cause the brine forming at the bottom of the well cavity to rise in the pipe 9, and out through the pipe 22.

The pressure of the water entering through pipe 24 must be sufficient to raise the heavier solution to the top of pipe 9, which will depend upon the strength of the solution or brine.

In other words the brine is forced upwardly in pipe 9 by the combined pressures of the air and water in the cavity.

When fresh water is permitted to act upon the upper part of the salt bed, it will dissolve faster there, and a cavity will be formed in the shape of a cone with the point down. As soon as the sides of this conical cavity become so flat that the mud from the impurities will not slide down to the bottom of the tube 9, the dissolving is retarded and the capacity of the well is diminished.

To overcome this objection, in accordance with the present invention, air is pumped through pipe 10 and bell 11, until the cavity is filled with air, and the water is forced down to within four or five feet of the slots 28 in tube 9. This water will then dissolve horizontally, undercutting a shallow cavity at the bottom of the salt, which may be extended to a diameter of five hundred feet without caving of the rock salt.

The pressure is maintained exactly sufficient to lift the brine at the velocity required. When this pressure is slightly decreased, the water will rise and attack the roof of the undercut from below, the impurities falling away to the bottom of the cavity.

The efficiency of operation is thereby materially increased, since a large fresh surface of soluble is always exposed to the action of fresh solvent.

If, when the air is pumped in to fill this cavity 34, the annular space between pipes 8 and 9 is filled with water, the pressure required to force the water through the annular space will be decreased by the weight of the height of the water above the cavity. If the weight of this height of water is diminished by air bubbling up into this annular space, the pressure required to pump the water in, will be increased.

To prevent this upward bubbling of the air, means are provided for restricting the cross-sectional area of the passage between the annular space and the cavity 34. A bell 11 is shown in Fig. 2, or the deflector 35' shown in Figs. 1 and 4 may serve this purpose.

The water which is being forced into the top of the annular space, will be held back by the pressure of the air in the cavity and the decrease in area of the passage at the bottom of the annular space will cause the velocity of the water entering the cavity to be increased, which will prevent the entrance of air into said annular space, and the water will fall like rain through the air in cavity 34.

The deflecting and restricting actions of the top of the bell or of the special deflector may be further explained as follows:—Where the normal cross-sectional area of the said annular space, between pipes 8 and 9, is 15.7 sq. in. and there is no restriction in the passage between this space and the cavity 34, when 200 gals. of water are pumped in per minute, which equals 46,200 cu. in., the velocity will be nearly 300 ft. per minute or 5 ft. per second. This would be sufficient to prevent a bubble of air from rising through the descending water, without any decrease in the area of said passage. But if the quantity of water is reduced to 100 gals. per minute, to obtain the velocity of 5 ft. per minute, we must decrease the area of said passage into the cavity. This method has been found entirely satisfactory in actual practice.

By a proper control of the air volume, the water is permitted gradually or periodically to rise in the cavity 34, and the step by step dissolving proceeds in stages, as indicated by the broken lines 39.

This control may be effected in any suitable way, for example by closing valve 14 whereby the volume of air in space 34 will be reduced until the solvent rises to the level of the first broken line 39 and the air at this level will be maintained while the outward horizontal dissolving proceeds to the diameter of the undercut. This procedure will be repeated, stage after stage, until the dissolving of the entire bed is accomplished.

After completion of the undercutting the amount of air absorbed will be reduced because the area of contact of air with water will be much less within the space 34, than if the air cushion extended the whole size of the undercut. By operating in this way the water remains in contact with the salt all the time, and it would be eating upwardly continuously, the roof in the space 34 being still protected by the air. The roof of the entire cavity eventually becomes dome-shaped. The undercut should be made the maximum diameter, before the level is raised more than ten feet above the top of the openings 28, in the brine pipe 9.

In accordance with the arrangement shown in Fig. 4, a $5\frac{3}{8}$'' pipe or casing 36 is provided to surround the 4'' brine pipe 9, and is provided at its lower end with the bell 37, to which it delivers. The bell 37 surrounds the pipe 9. The pipe or casing 36 is connected at the top with an air supply pipe 38. The air, descending in pipe 36, acts in a way similar to the air passing down in the 1'' pipe 10 in Fig. 1. That is the operation of the device shown in Fig. 4, is similar to that shown in Fig. 1.

As in Fig. 1, the space between the broken lines 30 and 31, is filled with air, while the space between the broken lines 30 and 32, is filled with solvent, during the undercutting.

In accordance with the arrangement shown in Fig. 4, the bell entirely surrounds the brine tube 9. While it will have a similar deflecting action; this action will be more symmetrical, than when the bell is crescent shaped, as shown in Fig. 1.

The special deflector 35' may be so located and adjusted as to control or modify the action of the water upon the adjacent wall of the well, and also to reduce the interference between the downwardly moving water and the air within the cavity.

In the above description, the word soluble is used to mean salt or other mineral capable of being dissolved, the word solvent to mean any fluid medium capable of dissolving the soluble, and the word non-solvent any fluid medium, gas or liquid which will float upon the solvent and which will not dissolve the soluble.

What I claim is:—

1. In the operation of dissolving a soluble by introducing a solvent into a cavity made in the soluble, and discharging the resulting solution therefrom, the method which consists in introducing a non-solvent into the cavity and in deflecting the down flowing solvent outwardly as it enters the top of the cavity.

2. In a system for dissolving a soluble in a well and discharging the solution therefrom, the combination of means for introducing a solvent into the mine cavity, means for discharging the solution therefrom and means for introducing a non-solvent into the mine cavity for controlling the action of the solvent and a formation ad-

jacent the point of discharge of the solvent into the cavity, for throttling said discharge as and for the purpose described.

3. In the operation of dissolving a soluble by introducing a solvent into a cavity made in the soluble, introducing also a non-solvent for controlling the action of the solvent, and discharging the resulting solution therefrom, the method which consists in utilizing predetermined maximum and minimum pressures of the non-solvent in the cavity, automatically to regulate its introduction and thereby control the action of the solvent.

4. In the operation of dissolving a soluble by introducing a solvent into a cavity made in the soluble, introducing also a non-solvent for controlling the action of the solvent, and discharging the resulting solution therefrom, the method which consists in throttling the flow of solvent approximate the point of entrance to the cavity to prevent non-solvent passing upwardly through said entrance.

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