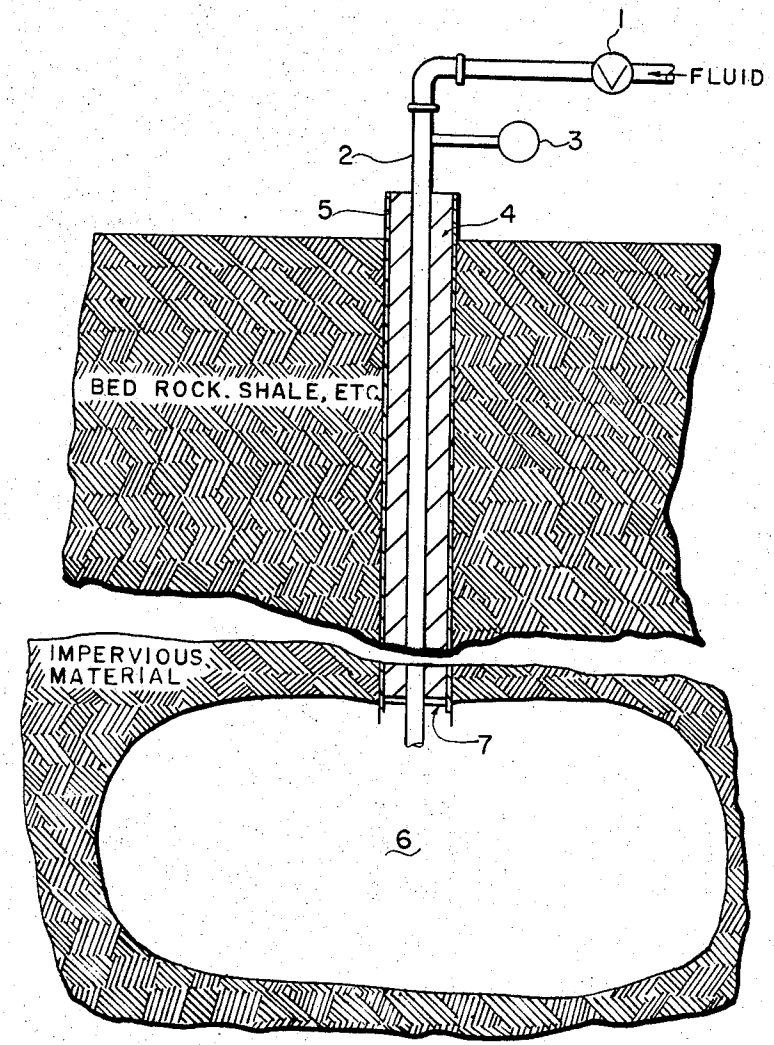
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METHOD OF INHIBITING EARTH SUBSIDENCE OVER A CAVITY

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METHOD OF INHIBITING EARTH SUBSIDENCE OVER A CAVITY

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This invention relates to providing against subsidence of the earth above a subterranean cavity. It more particularly relates to reducing the probability of subsidence of the earth above solution mining cavities when operations therein have been temporarily or permanently terminated.

The term "cavity" as used herein and in the claims, includes any cavity, void, hole, or space located in a subterranean formation. The pressure within such a cavity is typically less than the rock pressure adjacent the cavity. By "rock pressure" is meant the pressure existing in a subterranean formation.

In the mining of a soluble, techniques are frequently employed whereby a cased bore hole is sunk down through the earth to communicate with a mineable deposit. Solvent is passed through the bore hole into the deposit to dissolve the material contained therein. The resulting solution is withdrawn to the surface of the earth thereby establishing a cavity in the deposit being mined.

The aforedescribed solution mining techniques have been employed in the mining of sodium chloride, potassium chloride, sylvinite, trona, borax, and similar soluble salts. Similar techniques are employed in producing carbon dioxide gas from subterranean limestone deposits by introducing mineral acids thereto. In sulfur mining, superheated water is forced into a subterranean deposit. The hot water melts sulfur from the deposit. The molten sulfur is removed to the surface of the earth thereby creating a subterranean cavity.

Typically, cavities formed by solution mining techniques are of substantial proportions. Cavities developed in solution mining sodium chloride, for example, are often several hundred feet or more in diameter. The pressures within these cavities, especially when they are abandoned is substantially less than the surrounding rock pressure. A "low pressure" subterranean cavity which results from a terminated solution mining operation remains filled with fluid. It may be filled with liquids or it may be totally or partially filled with gases such as air.

The geometery of the cavity, specifically the ratio of its surface area to its volume is often an important factor affecting the economy of a solution mining operation. Thus, after a cavity has attained a certain size, the mining operation is usually terminated and the cavity is abandoned. Of course, mining operations may be temporarily or permanently discontinued for a variety of reasons. It has been observed that subsidence is probable above a cavity when mining operations are suspended.

Typically, there are no supporting columns within the cavity. In general, the probability of subsidence increases with increasing lateral cross section. As the vertical dimension of the cavity increases, the magnitude of the subsidence effect tends to increase. Thus if the vertical dimension of a cavity is several hundred feet, a substantial pit at the earth's surface may result as the surface subsides.

It has been suggested that when a cavity is located very deep, for example, more than 2000 feet beneath the surface of the earth, subsidence is less likely to occur due to the thickness of the material above the cavity. Subsidence has been observed to occur commonly where the cavity has been located at depths of up to 3000 feet. It is presumed that subsidence can occur over cavities located at much greater depths. Of course, the time which elapses

before subsidence occurs will depend on many factors, such as those hereinbefore considered and the nature of the material above the cavity.

Heretofore, subsidence has been a serious problem to solution mining operators. Because of the unpredictable and sometimes catastrophic results of subsidence, the ground space above a cavity has been considered dangerous. Thus, the value of property typically decreases when a cavity is developed underneath it. Insurance against subsidence is generally expensive. The location of subterranean cavities must be taken into account when locating plant and other facilities.

The principal cause of subsidence is thought to be the differential between the rock pressure of the formation in which the cavity is located and the pressure against the interior surface of the cavity roof. It is known that the rock pressure at any given point beneath the surface of the earth is dependent upon the density of the materials above that point. The material above a cavity is typically much more dense than the fluid in the cavity. In solution mining of sodium chloride, for example, it is a rule of thumb that at any given depth the pressure of a column of brine extending to the surface of the earth and open to the atmosphere will be approximately half the rock pressure at that depth. When a cavity and the casings communicating therewith are filled with brine, the pressure against the interior surface of the roof of the cavity is equal to this brine column pressure. Because of the differential in pressures existing above and below the cavity roof, the roof tends to cave successively. Thus, the cavity migrates vertically until ultimately the surface of the earth subsides into the cavity.

This invention solves the problem of cavity subsidence in a simple manner. According to this invention, the openings communicating with a cavity are sealed to create a sealed volume. Fluid is introduced into the sealed volume to establish and maintain a cavity pressure sufficient to prevent caving of the cavity roof. Subsidence of the earth's surface is thereby prevented.

The extent to which the cavity pressure must be increased adequately to provide against subsidence depends upon the actual rock pressure immediately above the cavity. In practice, this rock pressure is difficult to measure. The theoretical maximum rock pressure is a function of the thickness and densities of the earth materials above the cavity. These thicknesses and densities are typically determined from core samples taken through the earth above the cavity area.

The cavities being pressurized in accordance with this invention typically communicate with one or more openings, e.g., cased bore holes. These openings usually extend to the surface of the earth. The pressure exerted against the interior surface of the cavity roof is a function of the height and density of the column of fluid extending from the cavity roof up these openings. Thus, the pressure exerted against the cavity roof in a typical cavity communicating with the atmosphere may vary from atmospheric to the column pressure of a liquid extending up a column to above the surface of the earth.

The maximum pressure necessary to be applied to the cavity roof to equalize the cavity roof fluid pressure with the cavity roof rock pressure is obviously the theoretical rock pressure. Usually the fluid column does not supply this amount of pressure. Thus, an increment of pressure is added to the fluid column to increase the total pressure against the cavity roof. The actual pressure increment necessary to be added is usually less than the theoretical maximum. Actual rock pressures are usually less than, typically about 50 to about 100 percent, theoretical rock pressures.

It is not always necessary to establish a fluid pressure at the cavity roof as high as the adjacent rock pressure

to provide against subsidence. The minimum acceptable pressure increment varies from cavity to cavity. The desired increment may be expressed as the product of a factor multiplied by the longest distance in feet between the cavity roof and the earth's surface pounds per square inch (p.s.i. gauge). If it is desired to establish pressure against the cavity roof at least equal to the theoretical rock pressure, a factor equal to or in excess of 0.434 times the difference in average specific gravities of the fluid column and the materials in the earth above the cavity is used. 0.434 is the conversion factor to convert gm./cc. x feet to p.s.i.

A factor of from about 0.2 to about 1.1 is considered adequate to satisfactorily reduce the probability of subsidence over most cavities. A factor of about 0.05 has been determined to be the minimum acceptable factor in most cases. When the fluid used to pressurize a cavity is a gas, a factor in excess of 0.5 is usually preferred due to the low specific gravity of most gases.

The pressure increment can be read directly from a pressure gauge communicating with the sealed volume at a point above the liquid therein. If the gauge communicates with the liquid in the sealed volume, it may be calibrated to indicate directly this pressure increment. An uncalibrated gauge reading must be corrected to take account of the weight of the liquid above the gauge in order to determine the actual increment of pressure added to every point within the sealed volume.

The accompanying drawing diagrammatically illustrates a typical cavity which can be pressurized in accordance with this invention.

As illustrated by the drawing, a cavity **6** exists in a subterranean deposit. The material of the deposit is substantially impervious to fluid. That is, the nature of the material surrounding the cavity is such that the cavity will retain fluid pumped into it under pressure. Generally, materials which are plastic in nature, e.g., clay or an evaporite such as a sodium chloride deposit, tend to flow (become plastic) under pressure. Thus, plastic materials located well beneath the earth's surface tend to compact and are less pervious to fluids than materials such as limestone, granite, basalt, and similar rock-like materials.

Most deposits mined by liquid extraction methods, such as salt, trona, or sulfur, are plastic in nature and are located at sufficient depth beneath the surface of the earth to be rendered impervious to fluids. Thus, this invention is particularly applicable to cavities developed by solution mining methods. Although this invention is described with primary reference to cavities which have been developed through solution mining techniques, it is not limited in practice to such cavities.

The cavity will typically be located at least 200 feet below the surface of the earth. At lesser depths, other methods of mining are generally preferred over solution mining. Therefore, a cavity will not normally be developed at depths less than 200 feet. Cavities are sometimes located more than 5000 feet below the surface of the earth. This invention is equally applicable to any cavity in impervious material, no matter how far beneath the surface of the earth it is located.

A casing **4** communicates with the cavity **6**. Typically, this casing is the casing utilized in the subterranean solution mining operation. A smaller pipe **2** of any convenient diameter, but typically about 1 to 4 inches in diameter, is placed concentrically within the casing.

Typically, when a cavity is abandoned, it remains filled with a solution containing large quantities of the minerals from the mineable deposit in solution. Often, for example, in a salt or potassium chloride deposit, this solution is highly corrosive. Leaks are apt to occur through the casing if this corrosive solution is allowed to contact the casing over an extended period of time. If the leak occurs at a point where the casing passes through material which is pervious to the fluid in the cavity, the cavity will lose pressure. Thus, it is desirable to insulate

the casing from corrosive attack. It is particularly desirable to protect the portion of the casing which passes through pervious materials. This protection is typically accomplished by extending the pipe down to a level below the top of the impervious deposit and filling a portion or all of the annulus between the pipe **2** and casing **4** with an impervious substance **5**.

In order to effectively seal the cavity from the atmosphere and in order to protect the pipes from corrosion, several hundred feet of the annulus between the pipe **2** and the casing **4** is usually filled with material which is strong, corrosion resistant and impervious to the fluid in cavity **6**. The annulus is sometimes filled with fluid, e.g., oil, under pressure. Usually, a plug **7** is inserted in the annulus at the lowest point to which pipe **2** extends. The impervious material is then placed on top of this plug. Preferably pipe **2** terminates at the bottom of casing **4** and the entire annulus is filled with impervious material **5**.

The materials used to seal the annulus are usually poured on top of the plug in a flowable state. These materials then "set" in a solid state after a residence time of a few minutes to several weeks or more in the annulus. The plug is often attacked by the fluid in the cavity until it becomes porous. Thus, the material which seals the annulus should itself be resistant to corrosion by the fluids in the cavity.

Of course, it is not essential to fill the entire annulus with such material, it being important merely to seal the annulus against fluids escaping from the cavity. Generally, filling about 200 to about 1000 feet of the annulus provides an acceptable seal. Suitable materials for this purpose include tar, pitch, asphalt, Portland cement, grout, and cements of various composition. Any material which resists corrosion by and is impervious to the fluids in the cavity may be employed. The selection of a suitable material obviously depends upon the nature of the cavity fluids.

After the annulus has been sealed, fluid is introduced into the cavity through pipe **2**. The entering fluid provides a fluid seal in pipe **2** thereby sealing the volume of the cavity and pipe. Sufficient fluid is introduced to this sealed volume to add the desired pressure increment to the fluid pressure existing adjacent the cavity roof. Under the static conditions existing in the sealed volume, the pressure at every point within the sealed volume is increased to the extent of this increment. This pressure increment is measured by gauge **3**. Valve **1** is then closed thereby mechanically sealing the volume. From time to time, gauge **3** is read and the pressure increment noted. If the pressure increment has dropped to below the desired level, valve **1** is opened and additional fluid is pumped into cavity **6**.

As previously noted herein, subsidence is often effectively provided against by establishing and maintaining the cavity pressure at much less than the maximum theoretical rock pressure outside the cavity. If the formation above the cavity is of a rigid character, merely decreasing the pressure differential between the interior and exterior of the cavity may be sufficient to prevent subsidence. Preferably, however, the pressure against the interior surface of the cavity roof should equal and may somewhat exceed the estimated rock pressure immediately above the roof of the cavity. In this manner, the probability of subsidence is reduced to an absolute minimum.

The rock pressure actually existing at a particular point is estimated by adjusting the theoretical rock pressure to take account of the rigidity of the various strata above the cavity. The permissible differential in the pressures above and below the cavity roof depends on the nature of the formations in which the cavity is located. Thus, the factor by which the distance of the cavity roof from the surface of the earth is multiplied to determine the pressure increment to be applied to the sealed volume varies from cavity to cavity. Where the distance is

measured in feet, and the gauge pressure is expressed in p.s.i., practical factors typically range from about 0.5 to about 1.0.

Fluids utilized by this invention may be gaseous, liquid, or a combination thereof. Any convenient fluid can be used; however, it is preferable to select a fluid which will neither react with nor dissolve the minerals of the deposit in which the cavity is located. Air or natural gases are most likely to be available for use. These gases generally do not react with the minerals surrounding the cavity to an appreciable extent.

The cavity will usually contain appreciable quantities of liquid. When the liquid is capable of dissolving large quantities of gas, care must be taken to add additional gas from time to time to maintain the desired pressure in the cavity. In the event a leak develops through the casing, the highly compressed gas may force substantial quantities of liquid out of the cavity.

It is usually preferable to remove all gases from the cavity. The desired pressure is then established by forcing sufficient liquid into the cavity to accomplish this purpose. Liquid is generally preferred over gases to pressurize the cavity because the materials surrounding a cavity are typically less permeable to a liquid than to a gas. In addition, because liquids are much less compressable than gases, very little liquid will be forced from the cavity in the event a leak develops.

It is desirable that the pipe **2** or the casing **4** remain filled with liquid in the event of a leak. Otherwise the only fluid pressure exerted against the cavity roof is that of a column of air. This pressure is only slightly greater than that exerted by the atmosphere. Thus, the pressure differential which causes subsidence is maximized when compressed gases force liquid from the cavity.

Although any commonly available liquid such as water or undistilled pertoleum may normally be utilized by this invention, a solution substantially saturated with the minerals in the deposit surrounding the cavity is often preferred. Where such a solution is utilized, pressures are more quickly established within the cavity because there is little tendency for additional minerals to dissolve into solution.

Frequently, a solution occupies less space than the combined space occupied by the pure solvent and pure solute. A brine containing about 30 grams of sodium chloride and about 10 grams potassium chloride per 100 grams of water, for example, occupies only about 98 percent of the combined volumes occupied by the pure water and the undissolved minerals. Thus, if water is fed to a cavity located in a deposit substantially composed of sodium chloride and potassium chloride, care must be taken to maintain the desired pressure. As the material surrounding the cavity is dissolved the cavity volume increases more than the total volume of liquid in the cavity increases. It is thus necessary to add water from time to time to re-establish the pressure within the cavity. Eventually, the cavity solution will come into equilibrium with the deposit in which it is contained. Equilibrium is established much quicker when an aqueous solution containing substantial quantities of the soluble materials of the deposit is introduced initially.

As noted previously herein, whether gas or liquid is forced into the cavity to establish the requisite cavity pressure, it is typically necessary to add fluid from time to time to compensate for losses in pressure. According to the preferred embodiment of this invention, fluid is pumped into the cavity until the gauge **3** registers the desired pressure. Valve **1** is then closed. Gauge **3** is read periodically. When the gauge indicates a substantial drop in pressure, valve **1** is opened and sufficient additional fluid is forced into the cavity to re-establish the desired pressure.

Typically, the cavity pressure, once established, is not allowed to drop more than 10 percent. Often, additions of fluid become necessary less frequently as time passes. Sometimes, a cavity will maintain the desired pressure permanently, or at least for very long periods of time, without being fed additional fluid. In some instances, fluid is continuously lost from the cavity through minor leaks. Fluid is then either added continuously or at intervals to maintain the desired pressure.

Sometimes the roof of a cavity extends nearly to the top of the deposit of impervious material in which the cavity is located. Often, the strata above the impervious deposit is pervious to the fluid used to pressurize the cavity. The cavity will lose its ability to hold pressure if the impervious material remaining at the top of the cavity is dissolved by the fluid in the cavity. Thus, it is often desirable to introduce to the cavity a non-solvent fluid which is immiscible with the solvent fluids in the cavity and which will stratify at the top of the cavity. By non-solvent fluid is meant a fluid which will not dissolve the minerals of the deposits.

The non-solvent fluid typically has a specific gravity lower than the specific gravity of any solvent fluids in the cavity at the temperature prevailing in the cavity. Suitable non-solvent fluids include gases but are preferably liquid hydrocarbons, such as refined or nonrefined petroleum oil. Often considerable amounts of such fluids remain in the cavity when it is abandoned. Sufficient non-solvent fluid should be present in the cavity to insulate the roof of the cavity from the dissolving action of the solvent fluids in the cavity. Normally, a layer of non-solvent fluid about ¼ to about 20 inches thick at the roof of the cavity is sufficient for this purpose. When the solvent fluids in the cavity contain sufficient dissolved minerals from the deposit so that equilibrium is established between the minerals in solution and the minerals in the deposit, the protective layer of non-solvent fluid is usually unnecessary.

Frequently, an abandoned cavity will be in communication with a plurality of cased bore holes. In that event, especially if gases are eliminated from the sealed volume, pipes are often fitted in a plurality of these cased holes. One such pipe is used as the introduction pipe while the others are sealed. If a leak develops in the introduction casing due to corrosion or other causes, that casing is sealed. The pipe located in one of the other casings then serves as the introduction inlet for fluid to the cavity.

The following specific examples will serve to further illustrate the invention.

EXAMPLE 1

A cavity is situated in a strata containing the following approximate composition:

	Percent by weight
NaCl	90
$CaSO_4$	2
KCl	2
Water soluble calcium and magnesium salts such as $MgCl_2$, $MgSO_4$, $Ca(HCO_3)_2$	2
Water insoluble material	4

Standard well logging techniques indicate that the cavity is about 200 feet in diameter and has a volume of about 4,000,000 cu. ft. The cavity roof is located approximately 3000 feet below the surface of the earth. A stratum of clay exists above the cavity at a distance ranging from about 2 to about 200 feet above the cavity roof. Two casings 7 inches in diameter communicate with the cavity.

The casings are laterally separated at the surface of the earth by a distance of about 100 feet. Into each of the casings is concentrically placed a 4½ inch diameter pipe. Each pipe extends to the bottom of the casing in which it is located. Each casing and each pipe terminates about 10 feet below the roof of the cavity. The annuli between the pipes and the casings are plugged and filled with cement along the entire length of the casings. The pipes extend above the casings.

The cavity is nearly filled with an aqueous solution con-

taining all of the soluble minerals of the deposit in which the cavity is located. An oil layer approximately 5 inches thick which was introduced during the operation of the cavity floats on the cavity solution and prevents contact of the cavity solution with the cavity roof. Approximately 10,000 gallons of water are added to completely fill the cavity and the pipes. The specific gravity of the cavity solution is calculated to be about 1.23. The average specific gravity of the earth above the cavity is calculated from core sample data to be about 2.57. The rock pressure above the formation is estimated to be about 80 percent theoretical.

One of the pipes is capped. The other pipe is fitted with a pressure gauge and a suitable valve. When closed, the valve mechanically seals the pipe.

The pressure increment to balance theoretical rock pressure is the product of the difference between the specific gravities of the rock material and the cavity solution (1.34 gm./cc.) times the depth of the cavity roof (3000 feet) times the conversion factor (0.434 p.s.i./gm. ft./cc.). This product is determined to be about 1,745 p.s.i. The actual increment added is only 80 percent of that calculated above, i.e., about 1400 p.s.i.

The valve is opened and additional water is pumped into the cavity until the gauge registers about 1400 p.s.i. gauge pressure. Approximately 1000 gallons of water are required. The valve is then closed. After a period of several days, it is observed that the gauge pressure has fallen to about 1,300 p.s.i. Additional water is pumped into the sealed volume until the gauge pressure returns to about 1,400 p.s.i. The gauge is subsequently checked periodically and additional water is added as needed to maintain the gauge pressure at above about 1,375 p.s.i.

EXAMPLE 2

A cavity similar to the cavity of Example 1 is situated in a deposit such that it intersects two strata of impervious materials. The approximate composition of the upper strata is:

	Percent by weight
KCl	18
$CaSO_4$	5
Water soluble calcium and magnesium salts such as $MgCl_2$, $MgSO_4$, and $Ca(HCO_3)_2$	2
Water insoluble material	5
NaCl	Remainder

The approximate composition of the lower strata is:

	Percent by weight
KCl	5
Water insoluble material	5
$CaSO_4$	3
Water soluble calcium and magnesium salts such as $MgCl_2$, $MgSO_4$, $Ca(HCO_3)_2$, etc.	2
NaCl	Remainder

The cavity is filled with an aqueous solution of the following approximate composition:

	Grams per 100 grams of water
NaCl	30
KCl	10
Other soluble minerals such as $CaSO_4$, $MgCl_2$, $MgSO_4$, etc.	About 1

This solution fills the entire cavity and the pipes. The specific gravity of the solution is about 1.21. All other conditions are as in Example 1.

The valve is opened and approximately 500 gallons of solution of the approximate composition of the cavity solution is pumped into the pipe. The gauge registers a pressure of about 1,350 p.s.i. The pipe is mechanically sealed by closing the valve. The gauge is read periodically. After 4 hours, the gauge pressure has dropped to about 1,300 p.s.i. The valve is opened and about 100 gallons of solution is pumped into the pipe until the pressure gauge indicates a pressure of at least 1,350 p.s.i. The valve is again closed and the gauge is read periodically for 100 days. It is found unnecessary to add further solution.

EXAMPLE 3

One of the casings communicating with the cavity of Example 2 is plugged at a point below the top of the impermeable deposits. The casing is filled with concrete above the plug. Air is pumped into the sealed volume rather than aqueous solution. It is necessary to add air frequently during the first 100 days to maintain a gauge pressure of 2,600 p.s.i. The time intervals between additions becomes increasingly longer. The interval between the first and the second additions is about one day. After 20 additions, the gauge pressure decreases to 2,500 p.s.i. and remains at that level without further additions of air.

EXAMPLE 4

A cavity is situated in a sulfur deposit approximately 500 feet beneath the surface of the earth. The rock pressure immediately above the cavity is estimated to be about 550 p.s.i. The cavity and all communicating openings are filled with water containing minor amounts of minerals. The column pressure, due to the weight of the water above the cavity roof is approximately 217 p.s.i. The cavity is surrounded with substantially pure sulfur containing some other water insoluble minerals and only traces of water soluble minerals.

Several casings communicate with the cavity. All except one of these casings is capped, A one inch pipe is fitted concentrically within the remaining casing as in Example 1. Water is pumped through the pipe until the gauge registers a pressure of 330 p.s.i. It is found that this pressure is maintained without further additions of water.

Although the invention disclosed herein has been described with reference to specific details of certain embodiments hereof, it is not intended that the details be regarded as limitations on the scope of this invention except insofar as they are included in the accompanying claims.

I claim:

1. A method of providing against subsidence of the earth over an inactivated fluid containing cavity which comprises sealing said cavity against flow of fluid therefrom and adding fluid to said sealed cavity to establish and maintain a fluid pressure against the roof of the cavity sufficient to inhibit subsidence of the earth over said cavity.

2. A method of providing against subsidence of the earth above an inactivated subterranean cavity which comprises sealing said cavity to prevent flow of fluid from said cavity and introducing sufficient fluid to the cavity to establish and maintain fluid pressure in p.s.i. gauge at all points within the sealed volume of at least 0.05 times the longest vertical distance in feet between the cavity roof and the surface of the earth.

3. The method of claim 2 wherein the minimum pressure in p.s.i. gauge at every point within the sealed volume is established and maintained between about 0.2 and above 1.1 times the longest distance in feet between the cavity roof and the surface of the earth.

4. The method of claim 2 wherein the pressure at all points within the sealed volume is established and maintained above a gauge pressure in p.s.i. of 0.434 times the product of the longest vertical distance in feet of the cavity roof beneath the surface of the earth and the difference between the average specific gravity of the earth materials above the cavity and the average specific gravity of fluid situated within said measured distance and communicating with said cavity, said specific gravities being expressed in grams per cubic centimeter.

5. A method of providing against subsidence of the earth above a solution mining cavity in which operations have been terminated said cavity being located in a deposit of material substantially impervious to fluid which

comprises sealing the cavity, introducing fluid through a pipe communicating with the cavity thereby establishing a pressure in p.s.i. gauge at all points within the sealed volume above 0.05 times the longest vertical distance in feet between the cavity roof and the surface of the earth and continuing to introduce fluid to the cavity as required to maintain said pressure.

6. A method of providing against subsidence of the earth above a solution mining cavity in which operations have been terminated said cavity being filled with fluid and located in a material substantially impervious to fluids which comprises bringing a casing into communication with the cavity, placing said pipe concentrically within a casing, sealing the annulus between the casing and the pipe with a material impervious to fluids, sealing the cavity from the atmosphere, introducing fluid through the pipe to the cavity until the fluid pressure in p.s.i. gauge at every point within the sealed volume is at least 0.05 times the distance measured in feet between the cavity roof and the surface of the earth, and introducing additional fluid to the cavity from time to time as required to maintain said fluid pressure.

7. The method of claim **6** wherein the pipe extends down to within the impervious material in which the cavity is located.

8. A method of providing against subsidence of the earth above a non-operating solution mining cavity communicating with a casing and filled with fluid which comprises placing a pipe concentrically within said casing, sealing the annulus between the casing and the pipe, sealing from the atmosphere all openings to the cavity, introducing sufficient aqueous fluid through the pipe to the cavity to establish pressure in p.s.i. gauge at every point within the sealed volume of at least 0.05 times the longest vertical distance in feet between the cavity roof and the surface of the earth and introducing additional aqueous fluid as required to maintain such fluid pressure within the cavity.

9. The method of claim **8** wherein the aqueous fluid fed to the cavity is a solution containing the minerals of the deposit in which the cavity is located.

10. The method of claim **8** wherein the aqueous fluid is a solution substantially saturated with the minerals of the deposit in which the cavity is located.

11. A method of providing against subsidence of the earth above a non-operating solution mining cavity communicating with a casing and filled with fluid which comprises placing a pipe concentrically within the casing, sealing the annulus between the casing and the pipe, sealing at a point within the mineral deposit in which the cavity is located all other openings communicating with the cavity, introducing sufficient gaseous fluid through the pipe to the cavity to establish pressure in p.s.i. gauge at every point within the sealed volume of at least 0.5 times the longest distance in feet between the cavity roof and the surface of the earth and introducing additional gaseous fluid as required to maintain said fluid pressure within the sealed volume.

12. The method of claim **11** wherein the gaseous fluid is air.

13. A method of providing against subsidence of the earth above a non-operating solution mining cavity filled with fluid which comprises bringing a casing into communication with the cavity, placing a pipe concentrically within the casing, sealing the annulus between the casing and the pipe with a material impervious to fluids, sealing the cavity from the atmosphere, introducing fluid, including a nonsolvent of the material in which the cavity is located, said nonsolvent being immiscible with the other fluids present in significant amounts in the cavity and having a specific gravity lower than the specific gravity of such other fluids at the temperature prevailing in the cavity, to the cavity until the fluid pressure in p.s.i. gauge at every point within the sealed volume is at least 0.05 times the distance in feet between the cavity roof and the surface of the earth and introducing additional fluid from time to time as required to maintain said fluid pressure.

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