Jan. 19, 1971 S. W. PORTER 3,556,597

TELESCOPIC WASHDOWN LINER AND METHOD OF SOLUTION MINING

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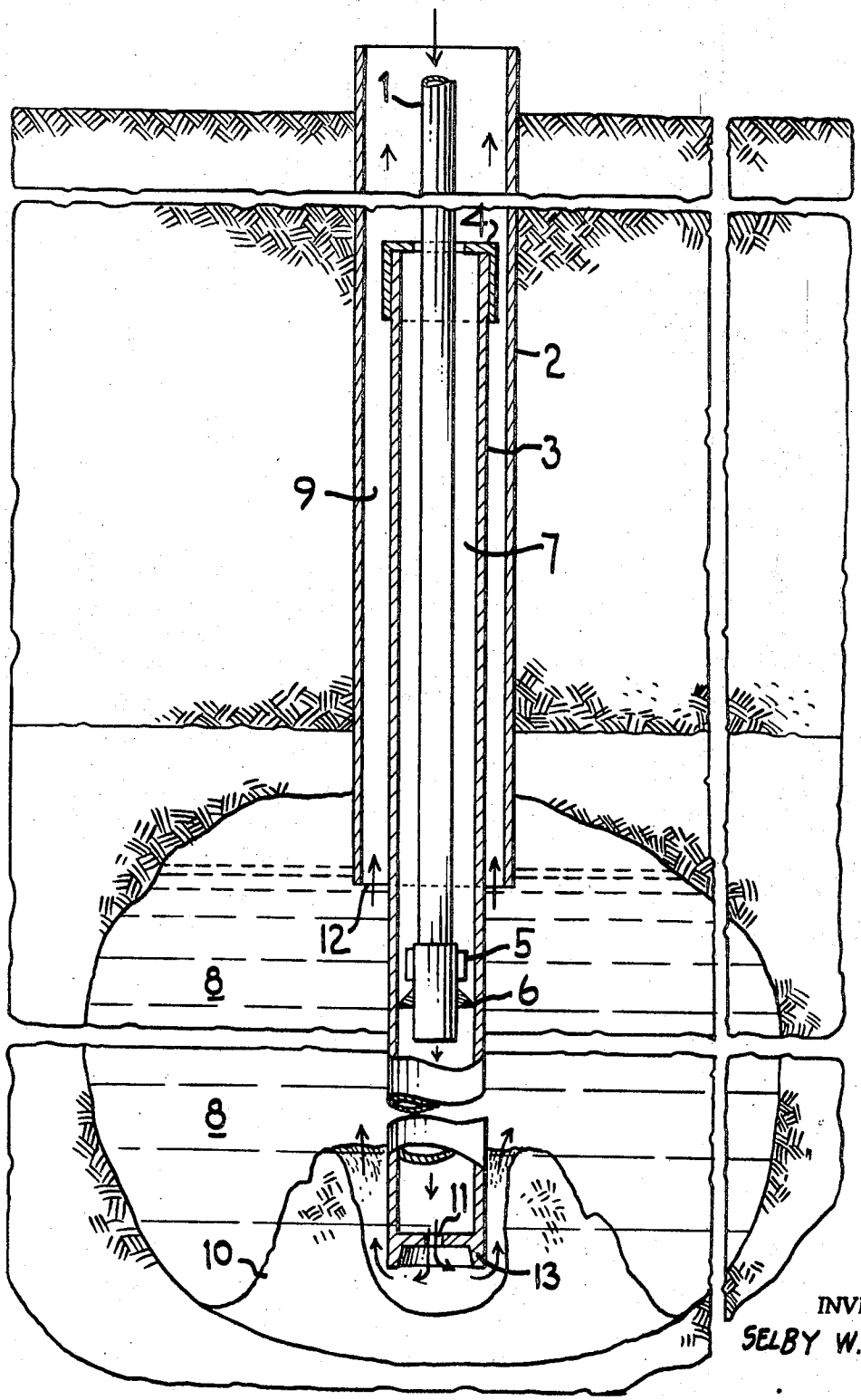


FIG. 1

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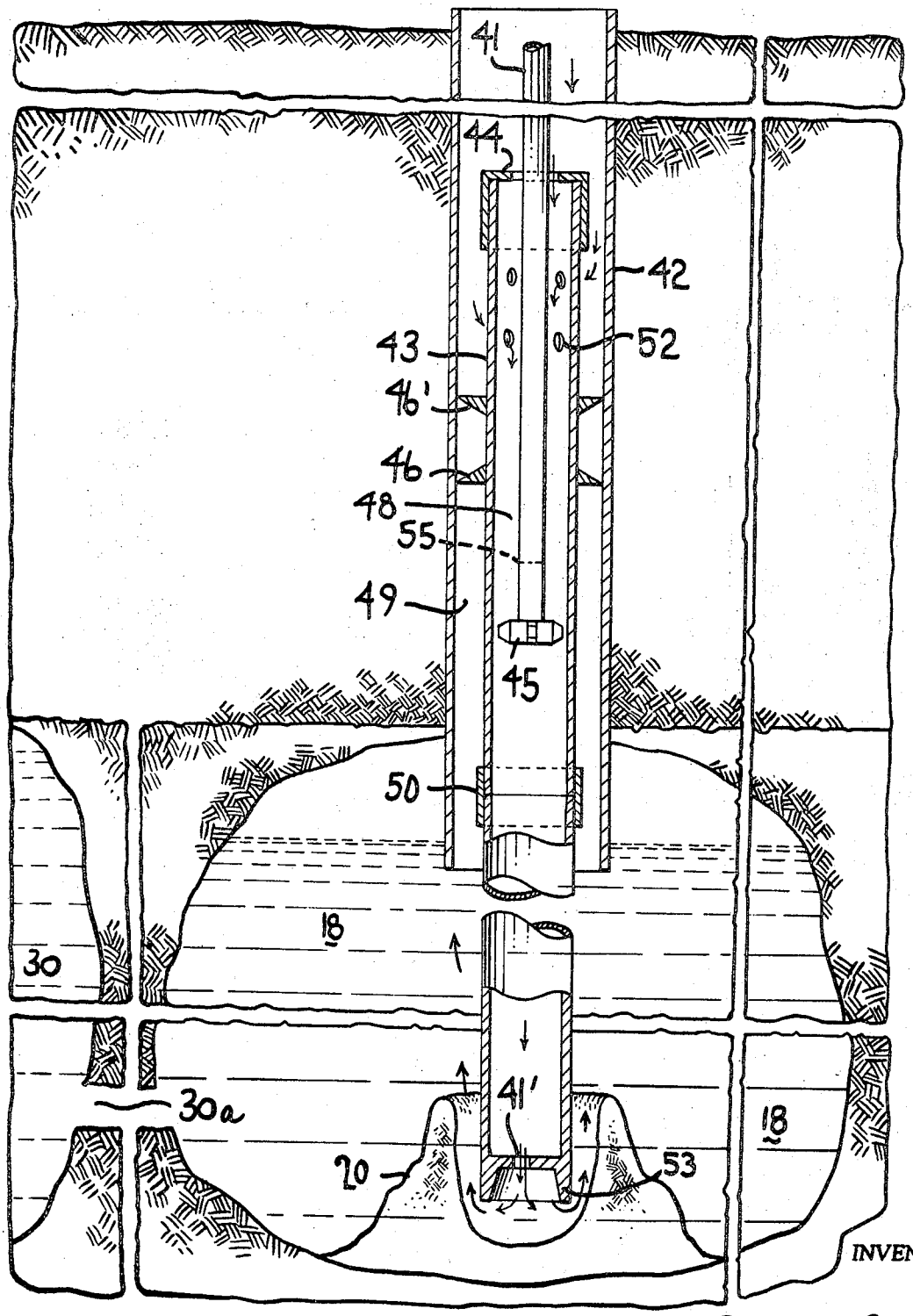


FIG. 2

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TELESCOPIC WASHDOWN LINER AND METHOD OF SOLUTION MINING

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ABSTRACT OF THE DISCLOSURE

A liner assembly attached to a drill string is described which permits solution mining of rubble piles located on subterranean cavity floors. The liner is sunk into the rubble pile and dissolution of the pile takes place by the introduction of fluid through the liner to the pile. A stop mechanism sets the liner in the pile at a fixed distance. Solution mining of the mineral content of rubble piles in a single hole cavity as well as from a plurality of interconnected subterranean cavities is disclosed. Specific apparatus is shown for each type of operation.

BACKGROUND OF THE INVENTION

In the solution mining of subterranean cavities having a considerable lateral dimension or form and located in soluble mineral deposits, suitable solvent is introduced into the minable deposit area dissolving the mineral content thereof. The dissolved minerals are removed from the cavity as a solution which is processed above ground for its mineral content. In the establishment of these subterranean cavities at large distances below the surface of the earth for example, 600 or more feet, typically 1,000 to 5,000 feet below the surface of the ground or more, and where a cavity having a considerable lateral expanse is achieved during the solubilization of the mineral deposite, typically 50 to 500 feet or more, roof collapsing occurs during the mining operation to a considerable extent. This roof collapsing causes the formation of large rubble piles on the cavity floor which contain quantities of minerals which are minable but are essentially out of contact with the solution in cavity due to their positioning in a pile formation on the cavity floor.

While it is desired to mine these materials, they must of necessity be brought into contact with solvent in order for dissolution of the minerals to take place. Thus, while it is desired to drill into a rubble pile a bore hole and set a liner in the hole drilled into such a rubble pile through which solvent can be introduced to contact the minerals located near the liner, this has presented a difficult problem. The large dimension of typical solution mining subterranean cavities and the small target that a drilled hole presents in a rubble pile on such a cavity floor renders it extremely difficult for a liner to be set in such a hole from the surface of the ground. Even when such a liner is placed in such a hole, the setting operation usually involves a considerable amount of development time and effort.

In accordance with the present invention a method and apparatus are presented for the purpose of setting a liner in a rubble pile on a cavity floor so the attendant difficulties normally associated with such an operation are not encountered. In accordance with this invention several embodiments are shown for placing a telescopic liner in a rubble pile located on a cavity floor in a cavity involved in subterranean solution mining operations. The invention is suitable for use in the operation of a single cavity solution mining operation as well as in solution mining operations involving the operation of more than one interconnected cavity.

The invention will be more readily understood by reference to the accompanying drawings and the ensuring description.

In FIG. 1 a suitable apparatus is shown for placing a liner in a rubble pile on a cavity floor and conducting satisfactory dissolution of the mineral content of such a pile for a single hole cavity.

FIG. 2 shows apparatus suitable for use in developing a rubble pile located on a cavity floor of a cavity which is in lateral subterranean communication with an adjacent cavity.

In FIG. 1 a unit is shown which is designed to wash and set the liner into a rubble pile on a cavity floor in a single hole cavity. As shown in the drawing, the apparatus consists of tubing string **1** having a liner member **3** attached thereto. The liner **3** is provided at its upper end with a liner stop member **4**. The tubing member **1** is provided with a tubing stop member **5** at the lower portion thereof and the conventional packer cup mandrel **6** which is affixed to the internal surface of the liner member **3**. The liner member **3** is provided on the bottom of its lower extremity with an opening **11**. The tubing string **1** and the associated liner member **3** are passed into the cavity **8** through a casing member **2**. Casing member **2** has a free open space or annulus **9** which is formed by the inner wall of the casing member **2** and the outer wall of the liner member **3**. The space or annulus **7** formed by the outer wall of the tubing string **1** and the inner wall of the liner member **3** is sealed by the packer mandrel **6** so that fluid flow through this space in an upward direction cannot occur. The member **1** is a cylindrical tube through which fluid can be passed.

In the operation of the device of FIG. 1 for the placing of the liner member **3** in a rubble pile **10** located at the base of a cavity **8**, the tubing string **1** and its associated liner member **3** are introduced into the cavity **8** to a point above the upper surface of the rubble pile **10**. Solution is introduced through the tubing member **1**, the lower part of the liner **3** and through the opening or nozzle **11** to the surface of the rubble pile **10** and dissolution of the material contained in the rubble pile begins. The liner **3** is preferably provided with an extension member, preferably in the form of a circumferential projection **13** which terminates below the orifice **11**. This provides the liner with a ridge on which to rest when it engages the rubble pile **10** and positions the orifice above the pile so that fluid can pass to the rubble pile from the orifice without plugging of the orifice. While it is preferable to utilize the construction shown in the drawing, other equivalent structures such as spaced projections from the liner wall, projections from the orifice plate itself in any shape could also be employed as long as the orifice is protected from the surface of the rubble pile. The device can be operated without such projection by introducing solution to the pile as the orifice **41'** approaches it, thus keeping the orifice open during its downward movement towards the pile surface. The mineral content of the rubble pile, as it is dissolved by the passage of the fluid out of nozzle or opening **11** in the liner **3**, flows as solution up into the cavity **8** and enters the annular space **9** through opening **12** located at the bottom thereof and rises vertically in the annular space **9** to the surface of the ground where it is processed for its mineral content.

As the dissolution procedure continues by the passage of solvent through the nozzle **11**, pressure is applied on the rubble pile by the weight of the liner **3** and the liner member **3** sinks deeper and deeper into the rubble pile until it is finally located at the bottom thereof. The stop member **5** on the tubing string is placed at a location such that the liner can be washed down in telescopic fashion until the stop **5** reaches and engages the stop

member 4 located on the liner. At this point the liner is permanently set in the rubble pile and will remain in this vertical position for dissolution of the content of the rubble pile until it is no longer economically feasible to dissolve further quantities of the minerals located therein.

In a further embodiment of the instant invention and with specific reference to FIG. 2, a method of setting a liner in a rubble pile positioned on the floor of a cavity in communication with a second cavity is shown. In this embodiment a telescopic wash down liner **43** is introduced through a casing **42** so that it is positioned above or in contact with a rubble pile **20** located on the floor of cavity **18**. The mineral content of rubble pile **20** in this embodiment is dissolved and the solution is removed through a cavity in communication with the cavity **18** as will be hereinafter explained.

In FIG. 2 a second cavity **30** is shown in communication with cavity **18** via a fluid travel path **30***a* formed in the deposit depicted. As shown in this figure, a tubing string or tube **41** is provided in casing member **42** and has associated therewith a liner member **43**. Liner member **43** is provided with a stop member **44** at the uppermost portion thereof and is provided in its lowermost portion with a nozzle, opening or nozzle member **41'**. Several sections of the liner may be provided utilizing one or more coupling members **50**. The tubing string **41** is provided with a stop member **45** and the outside of the liner member **43** has positioned thereon conventional packer cup mandrels **46** and **46'**. The liner member **43** is provided in its uppermost portion with a plurality of openings **52** for the introduction of fluid into the liner assembly so that fluid can pass down the annular space **48** formed by the inner walls of the liner **43** and the outer wall of the tube **41** in the position shown. The annular space **49** formed by the outer wall of the liner member **43** and the inside wall of the casing member **42** located below the packer cup mandrels **46** and **46'** is sealed so that no fluid can flow from the cavity **18** through this annulus and up the casing **42**. The holes **52** provided in the wall of the liner member **43** permit fluids to be circulated into the annular space **48**. Fluid passing downwardly through the annulus **48** exits through the nozzle or opening **41'**. The bottom of the liner preferably has a spacing member **53** which is preferably a circumferential projection, to maintain the nozzle **41'** above the rubble pile **20**. The spacing member attached to the liner or plate in which the nozzle is located may take any convenient form so long as it provides spacing in a vertical direction between the nozzle **41** and the rubble pile **20** so that fluid can be passed through the nozzle to the pile.

In the operation of the device shown in FIG. 2 a fluid is introduced into the casing **42** and passes through opening **52** in the liner **43**. The fluids pass down the annulus **48** and exit from the liner through the jet **41** located at the bottom of the tool. The pressure drop across the jet plus the weight of the liner will continue to force the liner member **43** down through the rubble pile **20** as a dissolution of the mineral content of the rubble pile continues. The fluid containing dissolved minerals follows the circulation path generally indicated by the arrows located in the drawing in association with the jet opening **41'** and passes through pathway **30***a* into exit cavity **30**. While one single cavity is shown and one single pathway, it will be obvious that the invention may be practiced when dissolving a rubble pile in a single cavity with one or more associated cavities used as withdrawal points. When the wash down is completed and the liner has been set in the rubble pile or near the cavity floor (this can be checked by wire line methods conventional in the art) the bottom end of the liner may be perforated utilizing tubing perforators in the conventional manner to allow entrance of fluid back through the liner so that production from the bottom of the washed hole can be accomplished. Thus, the lining device **43** can be utilized with circulation for production from the bottom of the washed hole. In this instance fluid would flow from cavity **30** via **30***a* to the cavity **18** into the liner **43** through perforations in the wall thereof and out of cavity **18** to the surface of ground.

The tubing string **1** can be removed from the device of FIG. 2 as well as in FIG. 1 by simply cutting the stop member **45** off the tubing at the position indicated in FIG. 2 by the dotted line **55**, and the liner left as a free standing unit. If desired, a hold down device can be installed above and in communication with the liner to insure its maintenance in an upright position when left as a free standing unit.

Operating in this fashion it is possible with the instant invention to extract the valuable mineral content of large rubble piles located on the floors of subterranean cavities in an inexpensive and efficient manner. By utilizing the instant invention it is possible to set a liner in a rubble pile located in a subterranean cavity by passing it through the bore hole without experiencing the normal difficulties associated with such an operation. Using this invention the deposit in such rubble piles is washed uniformly as the liner is placed in the hole and the stop mechanism located on the tubing string can be positioned so that the liner rests firmly on, or approximately on, the cavity floor.

The method of the instant invention is especially useful in mining and recovering the KCl content of rubble piles in cavities formed in deposits of KCl with or without NaCl. Solvents typical of those used to dissolve KCl from rubble piles are water, sodium chloride brines, weak KCl brines and brines containing both NaCl and KCl. The choice of a particular solvent for any given rubble pile having a desired mineral therein which is to be recovered will differ as the mineral differs. This choice is of course within the skill of the art once the desired mineral is ascertained. Thus, limestone can be readily dissolved with HCl, NaCl can be dissolved with water, weak sodium or potassium chloride solutions and KCl can be dissolved with weak sodium or potassium chloride solutions and water. Other minerals will of course suggest other solvents.

As will be readily understood from the above description the apparatus and method of the instant invention provides for a satisfactory and efficient method of dissolving the soluble mineral content of large rubble piles located on cavity floors. While the invention has been described with reference to certain illustrative embodiments, it is not intended that it so be limited except insofar as appears in the accompanying claims.

What is claimed is:

1. A method of solution mining the mineral content of a rubble pile located on the floor of a subterranean cavity comprising introducing into a bore hole in communication with said cavity a liner member having associated therewith a tubing string, providing a fluid opening in the bottom of said liner positioned above a spacing member associated with the bottom of said liner and adapted to raise said fluid opening above material in contact with said member, lowering said liner until said member rests on the surface of said rubble pile, introducing a solvent for the mineral content of said rubble pile into the liner and through the fluid opening to thereby dissolve the mineral content of the rubble pile, permitting the liner to descend in said rubble pile as dissolution of the pile by the solvent continues and discontinuing the descent of said liner when it has reached a desired depth and removing dissolved minerals from the bore hole in a path separated from the solvent injection path.

2. The method of claim **1** wherein the rubble pile contains KCl.

3. A method of solution mining the mineral content of a rubble pile positioned on the floor of a first subterranean cavity in fluid communication with at least one other subterranean cavity comprising introducing a liner

through a bore hole in communication with said first cavity, said liner having associated therewith a tubing string, providing a fluid opening in the bottom of said liner and positioning said opening above a spacing means associated with the liner and adapted to maintain the opening above surfaces in contact with said spacing means, lowering said liner and tubing string until the spacing means contacts the surface of the rubble pile introducing solvent capable of dissolving minerals in said rubble pile through said liner to thereby dissolve and excavate the surface of said rubble pile, lowering the liner in said rubble pile by continuing the introduction of solvent thereto, discontinuing the descent of the liner when it has reached a desired depth in said rubble pile, sealing the liner and bore hole to thereby prevent fluid from passing upwardly and circulating the dissolved minerals from said rubble pile to said other subterranean cavity and removing solution from said other cavity for recovery of its mineral content.

4. The method of claim 3 wherein fluid circulation in said cavities is periodically reversed and dissolved minerals are thereby removed through said liner.

5. The method of claim 3 wherein the rubble pile contains KCl.

6. A liner assembly suitable for use in mining the mineral content of a rubble pile located on the floor of a subterranean cavity in communication with a bore hole comprising a tubing string constructed and arranged to permit fluid travel therethrough, a liner attached to said tubing string and slidably engaging said string in a vertical direction, said liner surrounding a part of the tubing string and terminating below the lowermost end of the tubing string when positioned in a bore hole, stop means associated with said liner and tubing string to limit the downward movement of said liner, a port located in the bottom of said liner and below the end of the tubing string, sealing means associated with the liner and the tubing string above said port and the lower end of the tubing string thereby preventing fluid flow upwardly inside of said liner to thereby force fluid entering the liner from the end of said tubing string through said port, said liner being positioned in a bore hole and dimensioned so that a fluid conduit is formed between the exterior wall of the liner and the interior wall of said bore hole.

7. A liner assembly suitable for use in mining the mineral content of rubble piles located on the floor of subterranean cavities comprising a tubing string constructed and arranged to permit fluid travel therethrough, a liner attached to said tubing string and slidably engaging said string in a vertical direction, said liner encompassing the bottom of said tubing string when positioned inside of said bore hole and terminating below the end of said string, stop means associated with said liner and tubing string to limit the downward movement of said liner, a port located on the bottom of said liner below the end of said tubing string, spacing means located below said port and adapted to maintain said port in a position above the lower surface of said spacing means when in contact with a surface and sealing means associated with the liner and tubing string above said port and the lower end of said tubing string to force fluid introduced through said tubing string to be discharged through said port.

8. A liner assembly suitable for use in mining the mineral content of rubble piles located on the floor of subterranean cavities comprising a tubing string constructed to permit fluid travel therethrough, a liner attached to said tubing string and slidably engaging said string in a vertical direction, said tubing string encompassing the lowermost portion of said tubing string, stop means associated with said liner and tubing string to limit the downward movement of the liner, a port located in the bottom of the liner below the end of the tubing string, spacing means located below said port adapted to maintain the port in the position above the lower surface of said spacing means when the spacing means is in contact with a surface, sealing means associated with the liner and the tubing string above the port and the lower end of the tubing string to prevent fluid flow up through the liner and to force fluid introduced through the tubing string to be discharged through the port, a casing circumferentially disposed around said liner thereby defining a fluid space between said casing and said liner.

9. A liner assembly suitable for use in mining a rubble pile located on the floor of a subterranean cavity connected to at least one other cavity in fluid communication therewith comprising a tubing string, a liner attached to said tubing string in a vertical direction, stop means associated with said liner and tubing string to restrict the downward movement of said liner, the said liner encompassing the lower end of said tubing string, a port located on the lower end of the liner, spacing means projecting below the port and adapted to maintain the port at a point above the lower surface of the spacing means when it is in contact with a surface, means on the liner to introduce fluid into an annulus formed by the inner wall of the liner and the outer wall of the tubing string to thereby provide a fluid path through said liner to the port, a casing circumferentially disposed around the liner to thereby define a fluid space between the casing and the liner, means to pass fluid through the interior of the liner to a rubble pile and to remove fluid through the fluid space defined by the casing and the liner.

10. The apparatus of claim 9 including means on the outside of said liner to seal said liner to the casing thereby to prevent free fluid flow through the fluid space formed by the liner and a casing.

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