US 20020029888A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2002/0029888 A1

Swensen (43) Pub. Date: Mar. 14, 2002

(54) GROUND WATER EXTRACTION METHOD AND SYSTEM

(76) Inventor: **Frederick B. Swensen**, Dayton, OH (US)

Correspondence Address:
WILLIAM WEIGL
1805 Conwood Dr.
Troy, OH 45373 (US)

(21) Appl. No.: **09/908,063**

(22) Filed: **Jul. 19, 2001**

Related U.S. Application Data

(63) Non-provisional of provisional application No. 60/226,019, filed on Aug. 18, 2000.

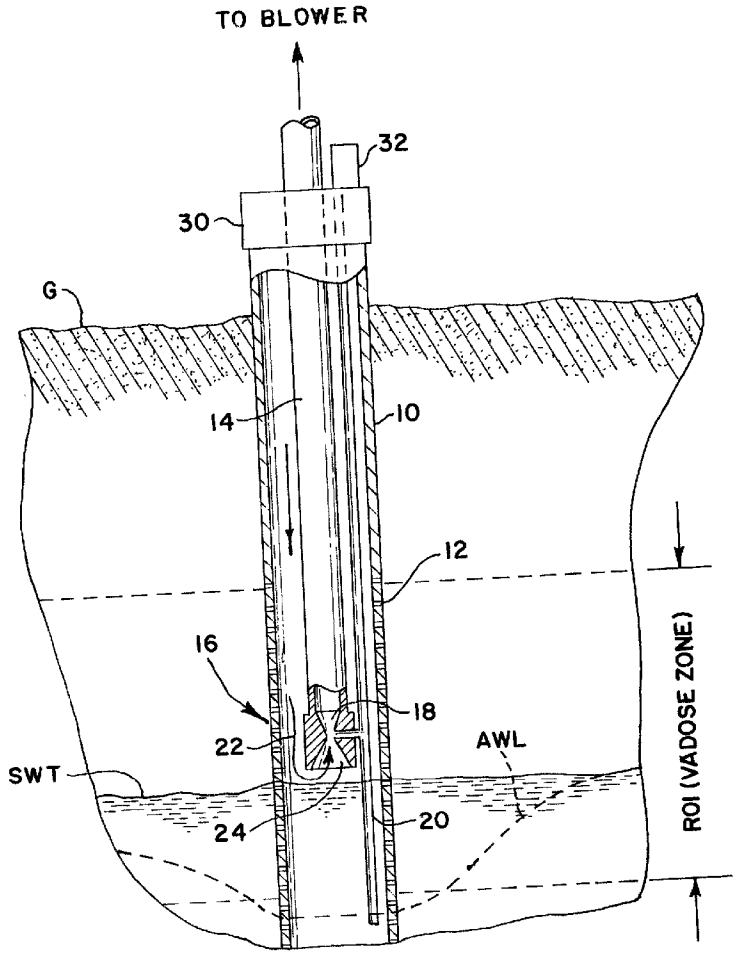
Publication Classification

(51) **Int. Cl.**[7] **E21B 37/00**; E21B 43/18

(52) **U.S. Cl.** **166/370**; 166/372; 166/68; 166/105

(57) **ABSTRACT**

A vacuum extraction tube is placed within a well casing which is permeable to gas and water at least within the vertical range of contaminated soil from which vapors and/or water are to be removed. The extraction tube has its lower open end extending a few inches above the water table. An internal venturi nozzle or passage adjacent the lower open end of the extraction tube is in exterior communication with one end of a siphon tube depending therefrom. The siphon tube has its opposite extend extending below the surface of the water in the casing, at least to a depth of contaminant-bearing soil from which vapors or water are to be removed. When vacuum is applied to the extraction tube through the exhaust end of a blower, self-priming air from within the casing is entrained upwardly through the open end of the extraction tube. As air velocity increases through the venturi passage, vacuum is created at the connection of the siphon tube to the venturi and lifts well water to the venturi passage where the water is atomized.



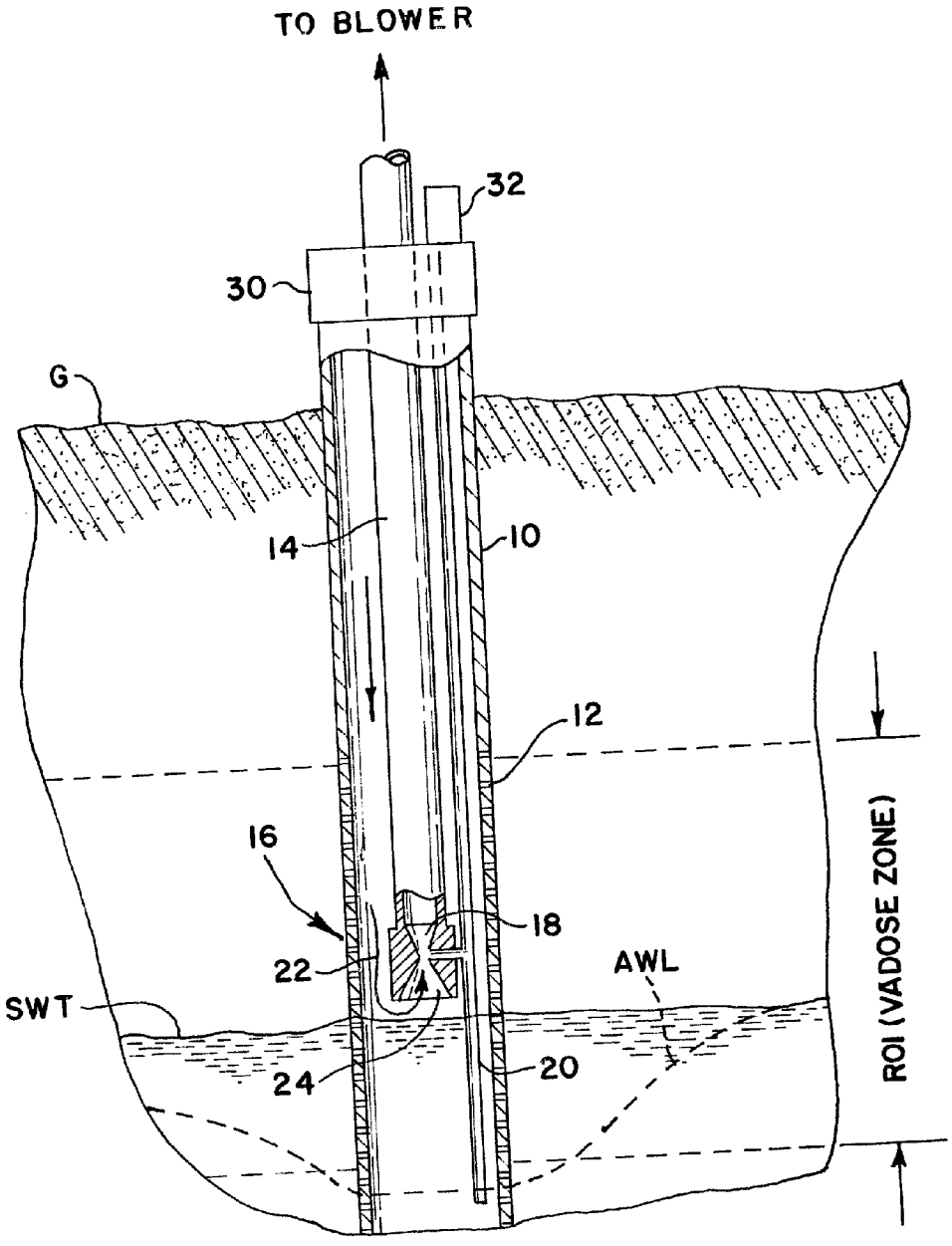


FIG. 1

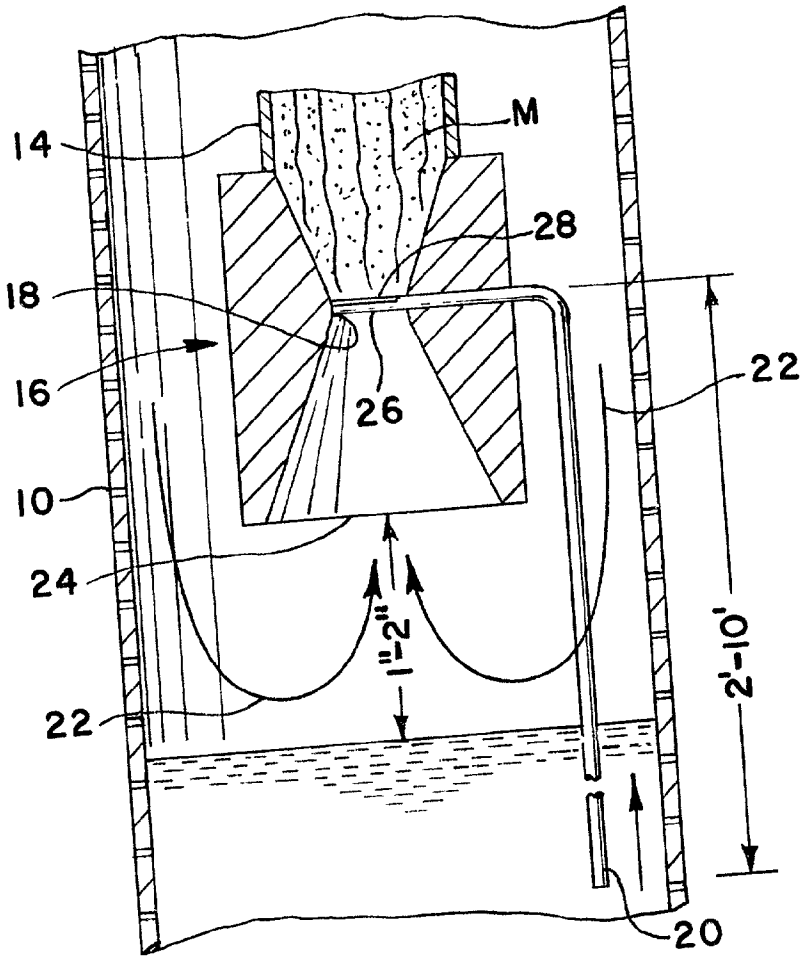


FIG. 2

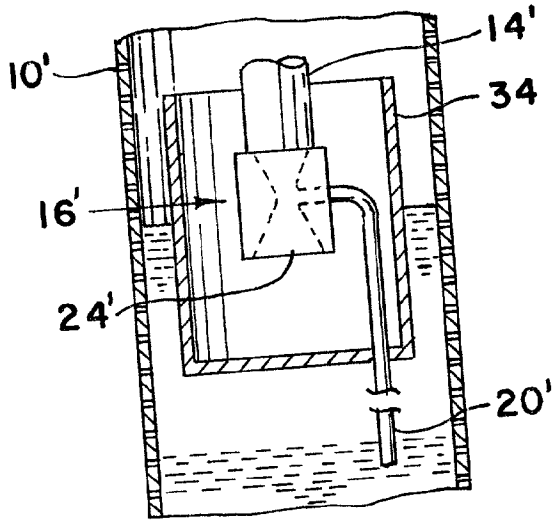


FIG. 3

GROUND WATER EXTRACTION METHOD AND SYSTEM

[0001] This invention relates to a method and system for lifting a liquid by means of vacuum from greater well depths than previously thought possible, and particularly to a method and system for extracting contaminating liquid or gas, or both, from subsurface soil for treatment and/or disposal at grade level.

BACKGROUND OF THE INVENTION

[0002] Since as early as the 17th century, it has been known that no vacuum pump has been able to lift a column of water more than about 34 feet above the level of a well when approximately at sea level. This is also recognized in U.S. Pat. No. 5,452,765 granted to Blanchard et al in 1995 where it is stated that "Conventional vacuum extraction systems are of limited usefulness where the depth to water exceeds about 33 feet since vacuum pumping cannot remove a column of water exceeding this height." The '765 patent discloses a system designed to enable more readily lifting of water to the surface from greater depths by permitting partial aeration of the column of water as it moves up a vacuum extraction tube on its way to the surface. The purpose of the aeration is to reduce the water's density. Water is removed from the well essentially in columnar form, with the percentage of aeration which is provided being dependent upon the pressure of the air within the well casing and the vacuum created by the rising column of water, so as to entrain air through an aperture or apertures into the extraction tube. The specification of the '765 patent states that the pressure in the annular area between the well casing and the extraction tube is preferably maintained slightly below atmospheric pressure. This would seem to somewhat resist the entrainment of air into the water in the tube, but may be necessary since the U.S. Environmental Protection Agency frowns upon allowing any air pressure to enter a well casing in a soil vapor extraction situation.

SUMMARY OF THE INVENTION

[0003] A vacuum extraction tube is placed within a well casing which is permeable to gas and water at least within the vertical range of contaminated soil from which noxious vapors and/or contaminated water are to be removed. The extraction tube has its lower open end extending to a point a few inches above the water table. An internal venturi nozzle or passage adjacent the lower open end of the extraction tube is in exterior communication with one end of a siphon tube depending from the extraction tube. The siphon tube has its opposite extend extending below the surface of the water in the casing, at least to a depth of contaminant-bearing soil from which contaminant vapors or water are to be removed. When vacuum is applied to the extraction tube through the intake end of a blower at grade level, self-priming air from within the casing is entrained upwardly through the open end of the extraction tube at a velocity depending on the capability of the blower and the air flow through the well casing. As air velocity increases through the venturi passage, a vacuum is created in conventional fashion at the connection of the siphon tube to the venturi and lifts well water to the venturi passage where the water is then atomized. Mist and rivulets of water deposited on the inner walls of the extraction tube move upwardly to the vacuum source. As the water table lowers within the casing, soil vapors which were formerly below the water table pass more easily through the permeable well casing and vapor extraction proceeds at a more rapid pace.

[0004] A primary object of the invention is to provide a method and system for vertically lifting a liquid through a tube by means of vacuum without concern of restricting natural phenomena as to the height the liquid may be lifted, by atomizing the liquid and lifting it primarily as a mist.

[0005] One specific application of the aforementioned method and system is its potential for use in lifting well water through a vacuum extraction tube from depths not thought possible when using vacuum as the power medium.

[0006] More specifically, an object is to utilize the invention in connection with the extraction of contaminant vapors from soil, which vapors lie in strata at least part of which extends below the static water table.

[0007] A specific object of the invention is to utilize the old and well-known venturi principle in connection with a vacuum extraction tube in a well casing, whereby a contaminating gas or water, or both, can be removed from sub-surface soil with less powerful and less costly equipment than heretofore required for evacuating contaminants from corresponding sub-surface depths and soil conditions.

[0008] Other objects and advantages will become apparent from the following description, in which reference is made to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] **FIG. 1** is a simplified elevational cross-sectional view of a well casing having a preferred form of my improved structure extending downwardly thereinto, for practicing the method of the invention.

[0010] **FIG. 2** is an enlarged fragmentary view of principal elements of the structure of **FIG. 1**.

[0011] **FIG. 3** is a smaller scale view similar to **FIG. 2** showing another embodiment of my invention, but utilizing a sump adjacent the lower end of the improved structure.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0012] Whenever an area of property is found to require cleansing of sub-surface vapors or volatile compounds which might have been left behind by an automotive service station or other business or industry, it is common to sink a number of wells within the confines of a region of interest ROI below grade level G. Each of the wells has a casing **10** of which at least the portion adjacent the vertical range of the ROI is permeable to vapors and water as shown by numeral **12**. A typical installation calls for the placement of a drop or extraction tube **14** into the casing and attachment of a blower (not shown) above grade level G for creating a vacuum in the tube. The ROI may be completely above a static water table SWT, is sometimes completely below the water table, but frequently extends both above and below the water table SWT. In the latter type of situation, if both vapor and water are contaminated, both must be extracted and treated in sufficient volumes to minimize the amount of time for clean-up to take place. In many situations, even though the ROI (oftentimes referred to in the industry as the vadose zone) may vertically overlap the water table, it may be

primarily the vapors that must be extracted, water decontamination being secondary. In such an instance, and particularly if the time period over which the clean-up operation may take place is not critical, the invention I am about to describe is particularly well-suited to the circumstances.

[0013] A venturi nozzle **16** having a reduced diameter passage **18** is formed or attached to the open lower end of the extraction tube **14**. As is well known, a venturi system is commonly used to create a vacuum by connecting a siphon tube **20** to the outside of the tube opposite the area of the passage **18**. As air flows in the direction of arrows **22** through the open end **24** of tube **14** toward the blower at grade level G, its velocity increases at the throat created by the reduced diameter passage **18**. This increased velocity decreases pressure in the siphon tube **20** below atmospheric, drawing water into the passage **18** and atomizing it due to the velocity of air flow at the point of entrance from the siphon tube **20** into the throat. To assist in the atomization, a hollow cross-tube **26** connected to the siphon tube **20** extends across the throat. Cross-tube **26** may have a slit **28** on its side opposite the open end **24** of tube **14**. As the water enters the extraction tube **14** via the siphon tube **20** and is atomized or otherwise converted into a mist M, the mist moves upwardly in the tube **14**. It has been noticed that some of the mist M quickly contacts the inner walls of the tube **14** and travels up the tube in the form of narrow rivulets R, shown simply in **FIG. 2** by a wiggly line. It is believed, but not known at the present time, that if the well water contains volatile organic compounds (VOCs) that also require removal from the water, the mist creation comprises an initial stripping step in decontamination of the water. If true, this can simplify the stripping of the VOCs or reduce the operating time of stripping equipment after removal of water from the well.

[0014] The example illustrated in **FIG. 1** shows a ROI that vertically overlaps the static water table SWT, i.e., it extends both above and below the static water table. On start-up of operation, the blower is activated, drawing air downwardly in the casing **10** and causing it to flow upwardly through the tube **14**. No priming is necessary, since the open end **24** of the tube **14** is located approximately an inch or two above the static water table SWT. The casing **10** is typically closed by a cap **30**. The cap may be vented to allow ambient air of the desired volume to enter the casing, or the system may be provided with a conventional vacuum relief valve **32**, shown as being mounted on the cap **30**. The vacuum relief valve **32** may be connected to the siphon tube **20** and maintain the pressure in the casing **10** at a sub-atmospheric pressure between 0" and 30" Hg. As air passes through the extraction tube **14**, it is replenished through the relief valve **32** or the vent, whichever is provided. The length of the siphon tube has no limitation except for the **34** feet mentioned at the outset, and is typically between two to ten feet long.

[0015] As previously described, the venturi **16** sucks water from below the static water table SWT, converts it to a mist and the mist travels upwardly through the tube **14**. Depending on several variables such as the permeability of the casing **10**, the recovery rate of water to its full static condition, the nature of the strata of the ROI, etc., the water level in the casing may drop from its static level SWT to an active water level AWL. This level is indicative of steady-state operation of the system in extracting vapors and liquid from the ROI. The ROI may extend vertically four feet, for example, two feet above and two feet below the static water table SWT. Thus, the lower end of the siphon tube for this example would preferably be about three feet below the venturi nozzle **16**. If the active water level AWL reaches and exposes the bottom of the siphon tube **20**, the tube **20** will merely suck air until the AWL returns to the bottom of the tube **20**. At that point, since the system is self-priming, it will commence action as before. During such period where the siphon tube **20** is above the AWL, vapors alone will be extracted through the tubes **14** and **20**.

[0016] With a two inch diameter extraction tube **14** and a ⅜ths I.D. siphon tube **20**, I have successfully used a 120 c.f.m. blower at 3" Hg. to lift water twenty five feet at the rate of ½ g.p.m. I did it with a system that is totally independent of the height to which the water must be lifted. I could just as easily have achieved the goal of lifting water fifty feet or more with the same effort and equipment. This is due to the creation of the mist through atomization. An advantage of using this approach for wells which do not require such great lift distance, is that I can obtain a reduced height lift with lower capacity and therefore probably inherently lower cost equipment. A typical installation may use a ten horsepower blower at 10" Hg. to move 100 c.f.m. of air.

[0017] **FIG. 3** is a view similar to that of **FIG. 2**, but on a smaller scale. In it, I illustrate a sump **34** into which the lower end of the tube **14'** leads. The sump may be utilized in situations where the water table SWT is capable of fluctuation due to its location, e.g., from excessive rainwater. The entire sump **34** may normally extend above the water table, but on occasion the SWT may rise above the lower end of the tube **14'**. To allow for easier self-priming, the sump keeps the lower end free of water unless it enters from above the top level of the sump. Where the SWT is below 34 feet, it is preferable not to use a sump because of the necessity to drain the sump with the vacuum on start-up. In such a situation, the lower open end **24** of the tube **14** should be kept above any anticipated static water table SWT.

[0018] While I have disclosed a venturi system to achieve atomization or mist creation, means other than a venturi may be possible. In its broadest sense, the liquid lifting capability by means of vacuum may be applicable to other situations that I have not considered yet. To the extent that other mist creating techniques may be utilized, or liquid lifting applications other than the one described are within the skill of persons working in the art, it is intended that they be encompassed within the claims.

[0019] Various other changes may be made without departing from the spirit and scope of the claims.

Having described my invention, I claim:

1. The method of in situ extraction of ground water from a well casing for use, treatment or disposal at a location remote from the well casing;

introducing an open-ended extraction tube into said casing;

connecting a source of vacuum to said tube remote from said open end;

providing for continuous flow of air through said extraction tube from within said casing above the water table and to a collection area associated with said source of vacuum;

converting water in said casing into a mist above the water table; and

extracting the mist and air by means of air flow within said extraction tube.

2. The method set forth in claim 1 wherein the mist conversion is produced internally of the open-ended extraction tube through atomization, said method further including the steps of providing a venturi passage adjacent the open end of said extraction tube and providing an elongated auxiliary siphon tube having one open end in communication with said passage and the opposing end immersed in water in said casing below the water table.

3. The method set forth in claim 1 including the further step of separately collecting water and air substances at said collection area, decontaminating at least one of said substances and discharging the substance upon achievement of decontamination to an acceptable level.

4. The method set forth in claim 2 including the further step of separately collecting water and air substances at said collection area, decontaminating at least one of said substances and discharging the substance upon achievement of decontamination to an acceptable level.

5. The method set forth in claim 4 including the additional step of providing and maintaining air pressure within said casing above the water table, said pressure being maintained at a level consistent with maximum flow of mist through said extraction tube.

6. Apparatus for practicing the method of claim 2, wherein said venturi passage is substantially annular.

7. Apparatus according to claim 6, wherein a cross-tube is connected to said siphon tube, said cross-tube extending laterally across said venturi passage and having an open elongated slit facing in the direction of air flow to maximize water extraction through said siphon tube and thereby enhance mist creation in said extraction tube.

8. Apparatus according to claim 7, wherein the liquid portion of said mist between said venturi passage and said vacuum source travels essentially as rivulets on the internal walls of the extraction tube.

9. Apparatus for practicing the method of claim 1 or **2** wherein volatile contaminants in the water are at least each partially stripped therefrom.

10. The method of in situ extraction of vapor from soil within a region of interest defined by strata having an upper and a lower level and which region lies at least partially below a water table in the soil, said method comprising the steps of:

providing a vertical casing from grade level to said region of interest, which casing is pervious to liquid and gas at least in the range of said region of interest;

providing a vacuum extraction tube having an open lower end, said tube extending downwardly from grade level to a point above the water table;

creating a vacuum in said tube at a flow rate sufficient to exhaust a mist of water and gas to grade level for collection of water and gas thereat;

converting standing water in said casing into a mist above the water level;

evacuating the mist through said tube by means of vacuum and delivering it to a collection station at grade level; and

continuing to evacuate water and gas in mist form simultaneously through said pervious portion of said casing while maintaining the level of water in said casing below the static water table, whereby contaminant vapor contained in said soil within said region of interest is continuously extracted therefrom and removed through said tube by vacuum.

11. The method set forth in claim 10 wherein the mist is produced by means of increasing the velocity of air flowing through said tube to create a vacuum at a port at the side of the area of increased velocity, and providing a siphon tube extending from said port to a level below the water level in the casing whereby to draw water through said siphon tube and atomize the drawn water as it enters said tube in the area of increased air velocity.

12. Apparatus for practicing the method of either of claims **10** or **11**.

* * * * *