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Gail et al.

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[54] FREEZE HOLE AIR BLEEDER SYSTEM

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[52] **U.S. Cl.** **62/230**, 62/85, 137/197, 165/45

[51] **Int. Cl.** **F25d 17/02**, F25l 43/00

[58] **Field of Search** ..... 62/475, 85, 260; 237/59, 63; 137/191, 202; 165/45; 61/36 A

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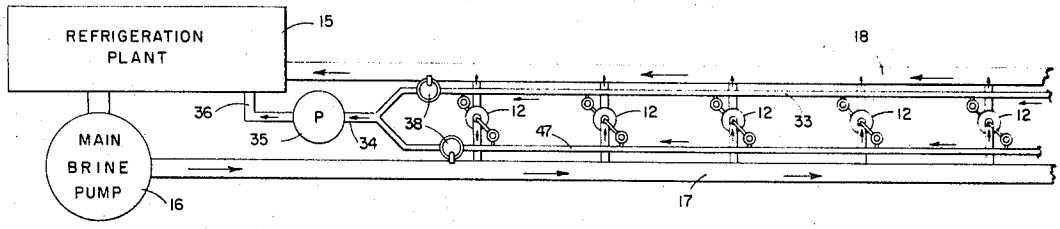
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[57] **ABSTRACT**

An arrangement for removing occluded air in a refrigerated liquid circulated through a plurality of freezing elements used in solidifying incompetent earth formations, which includes bleed lines extending from the freezing elements to manifolds positioned above the freezing elements, a valve in each bleed line controlling the flow to allow air and a minor amount of said liquid to be conducted therethrough, the manifold sloping downwardly to the inlet of a pump that returns the liquid from the manifold to the refrigeration plant, and float-operated vent devices connected to and positioned above the manifolds for collecting and discharging the air.

14 Claims, 7 Drawing Figures



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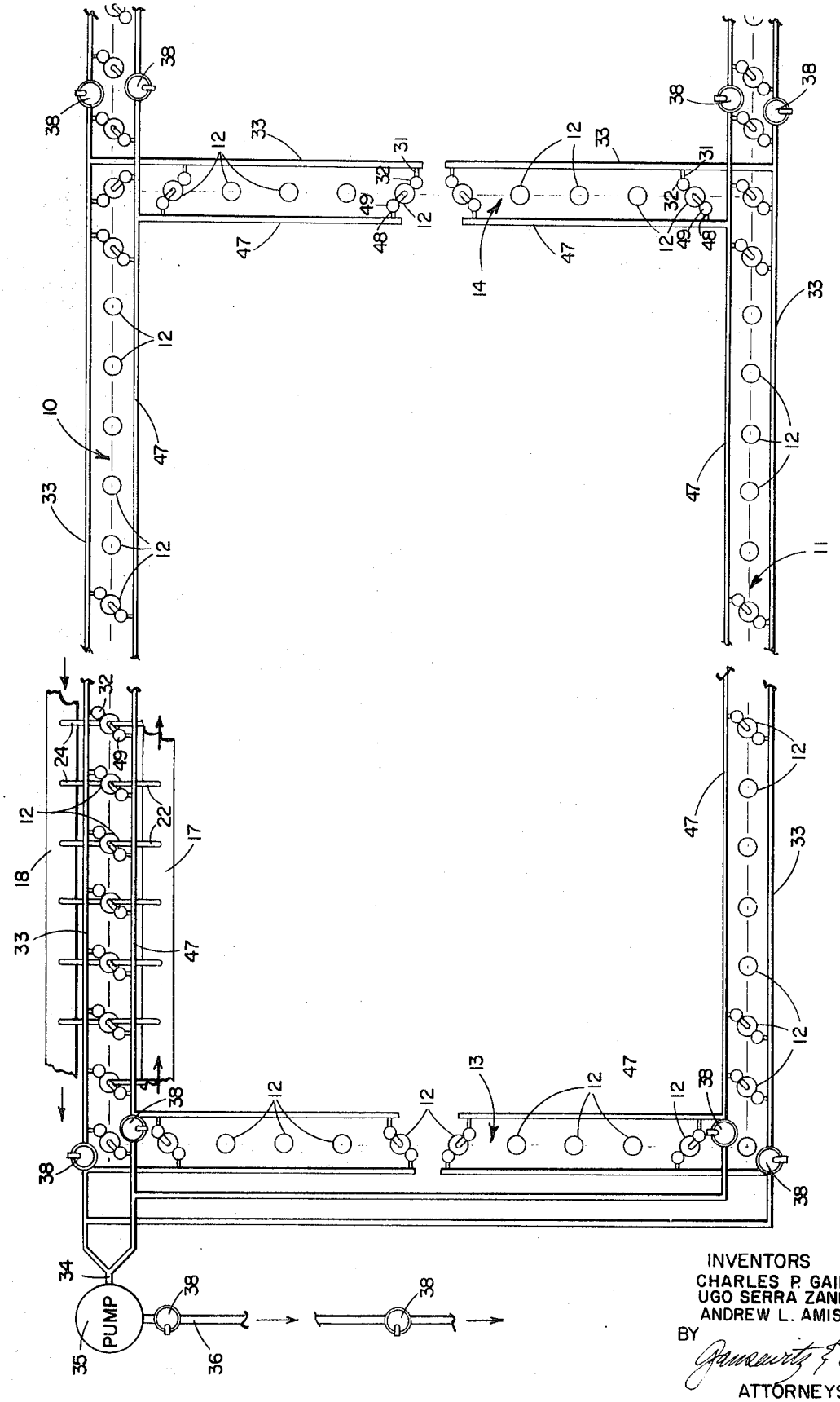


FIG. 1

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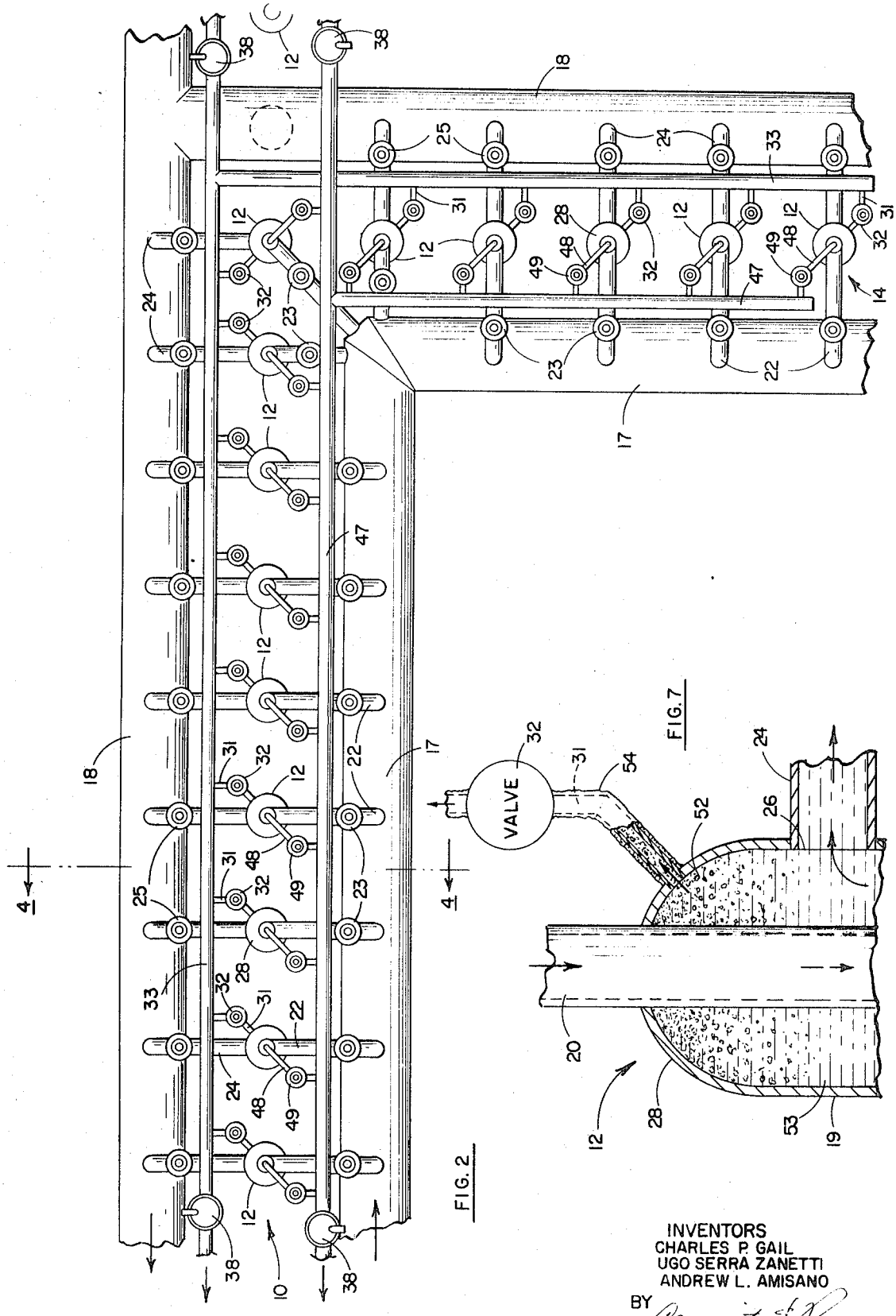


FIG. 2

FIG. 7

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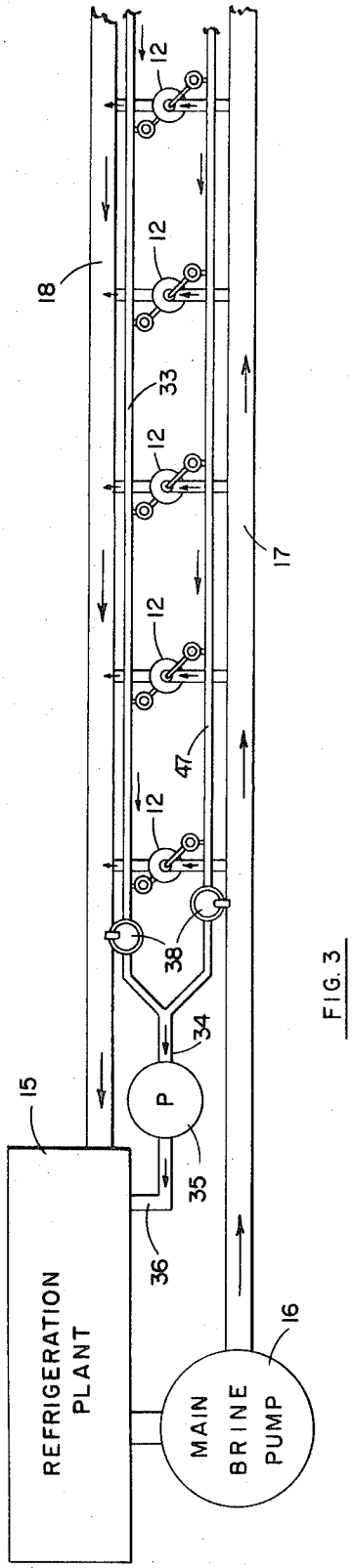


FIG. 3

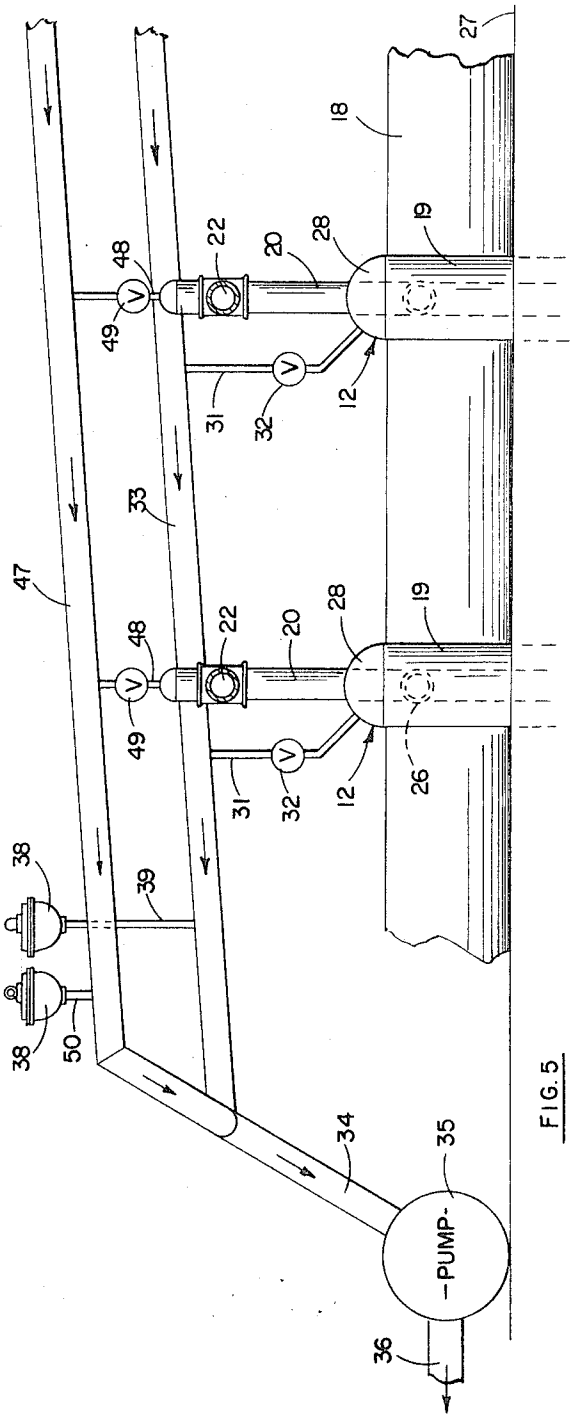


FIG. 5

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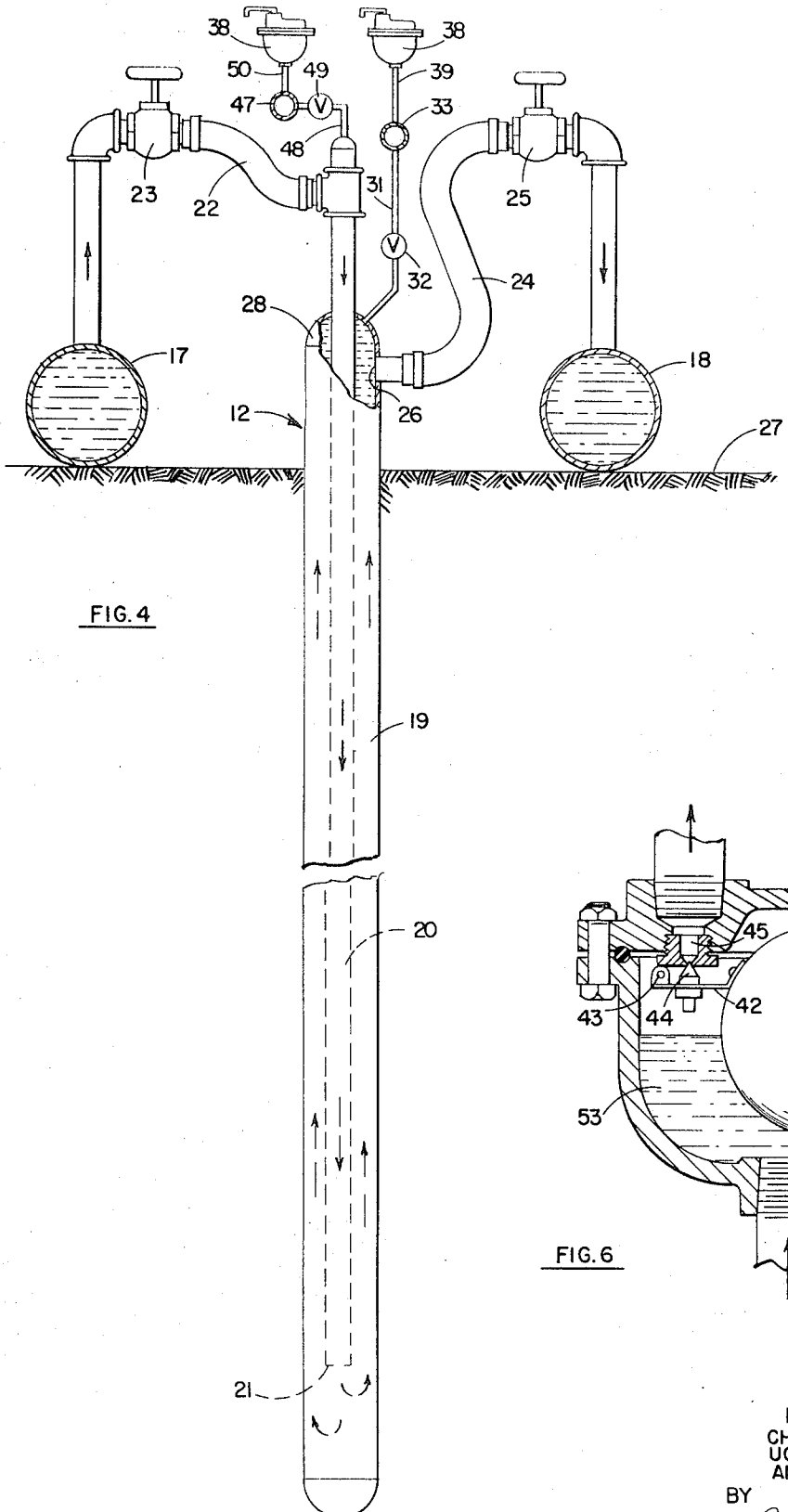


FIG. 4

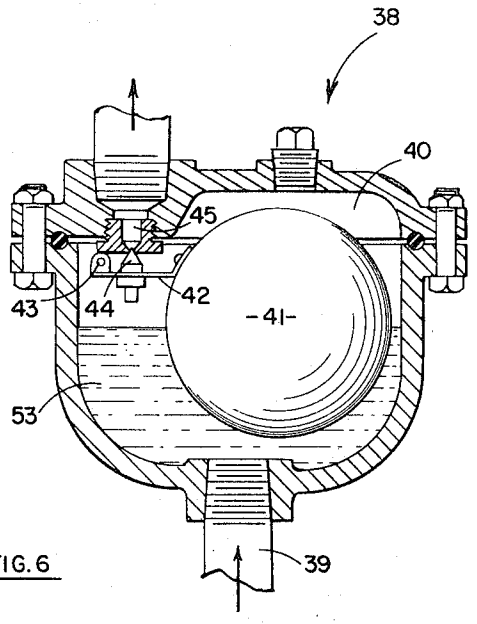


FIG. 6

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FREEZE HOLE AIR BLEEDER SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the field of freezing to solidify earth formations for excavation.

2. The Prior Art

Tunnels, shafts and other excavations may be formed in unstable formations by freezing the surrounding media to prevent the influx of water and soft material. In tunnel construction, this can avoid the alternative pressurization of the excavation site to hold back the flow of water and material into the excavation site, with its attendant expense and danger. Freezing can greatly speed the progress of the tunnel, and in some instances it may be the only technique that makes it possible for the tunnel to be constructed. In accomplishing the freezing, a number of vertical holes may be sunk into the ground around the area to be excavated, and a freezing tube inserted into each opening. Refrigerated brine is circulated through the freezing elements to lower the temperature of the surrounding formation to below the freezing point.

Conventionally, each freezing element includes an outer enclosed tubular member within which is a smaller tube having an open bottom end. Brine is admitted into the upper end of the smaller tube, flowing downwardly through it to discharge into the outer tubular member. This brine then is conducted through an outlet line that connects at the top of the outer tubular member to a return manifold that transmits it back to the supply source.

During the circulation of the brine in such a system, air becomes entrained with the liquid. This occurs primarily due to foaming and cavitation in the pumps, with the air leaking into the system through the pump glands. Subsequently, some of the occluded air will leave the brine as it circulates through the freezing elements, collecting at the inlets and the outlets of the freezing elements. As the air builds up, it occupies an increased volume, forcing the liquid level downwardly. Ultimately, the air occupies the space where the supply and outlet lines connect. This blocks the flow of brine so that brine no longer can circulate properly through the freezing element so affected. The accumulation of the air, therefore, prevents the freezing element from accomplishing its function of lowering the temperature of the formation around it.

This condition has been alleviated by providing a bleed line connecting to the top of the outer tubular member of the freezing element. A valve in this bleed line is opened from time to time to allow air to escape so that the return line is kept free. However, this requires constant attention to make certain that each freezing element is properly bled of air before too much air accumulates. This practice also wastes brine, as inevitably a quantity of brine is discharged as the air is bled from the freezing element.

The problem becomes acute when there are many freeze holes, such as in the system of our copending patent application Ser. No. 875,053 for Arrangement for Producing Tunnels, where walls of frozen material are produced to provide elongated enclosed chambers within which the excavation takes place. When there is a large number of freeze holes, several men are required to work around the clock in constantly bleeding the various freeze elements to keep them free. For example, in one project where 1,100 freeze holes were in operation simultaneously, five men were required at all times to continually bleed the freezing elements of air. This obviously is a significant expense to be borne by the tunnel construction project. With many freezing elements to be attended to, an added risk is run that some of the freezing elements will not be bled of air properly. Moreover, the brine loss is increased.

SUMMARY OF THE INVENTION

The present invention provides a means for automatically bleeding the air from the freezing elements of the freezing system to assure that the flow of brine never is blocked or obstructed. This is accomplished without loss of brine. In accordance with the present invention, a bleed line connects to the upper portion of the outer tubular member of each freezing element and extends upwardly to a manifold. A valve is in each of the bleed lines. The manifold slopes downwardly to a pump for returning brine to the supply source. Risers extend upwardly from the manifold to air vent traps that include float-operated air discharge valves. A similar bleed arrangement with a second manifold and group of air vent traps is provided for the brine supply connection at the inlet to each freezing element.

Air accumulating at the upper end of each freezing element, together with a small amount of brine, is discharged through the bleed lines into the manifolds. Air from the manifolds flows upwardly through the risers to the air vent traps. In the vent trap, the air displaces liquid to permit the float to drop, opening the outlet valve through which the air is bled to the atmosphere. Consequently, the brine that flows through the manifolds to the pump inlet is relatively free of air.

The valve in each bleed line is opened sufficiently to permit a small volume of brine to flow through it along with the entrapped air. This is to assure a flow adequate to remove enough air to keep the path through the freezing element free. The proper flow is detected visually by cracking the valve sufficiently to cause a thin layer of frost to appear on the bleed line. The presence of the frost indicates that brine is flowing through the bleed line, which means that sufficient air is being exhausted. The brine flow through the bleed line may be small so that the valve is set to a point where the frost layer is thin.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a plan view of a freezing system incorporating the present invention;

FIG. 2 is an enlarged fragmentary plan view of a portion of the system of FIG. 1;

FIG. 3 is a schematic view illustrating the hydraulic circuit of the system;

FIG. 4 is a sectional view taken along line 4—4 of FIG. 1;

FIG. 5 is a fragmentary elevational view of a portion of the system, illustrating the sloping connection of the bleed manifolds to the pump;

FIG. 6 is an enlarged fragmentary sectional view taken along line 6—6 of FIG. 2, illustrating the interior arrangement of the air vent traps; and

FIG. 7 is an enlarged fragmentary view of the upper portion of one of the freezing elements, showing the removal of air and liquid to prevent obstruction of the outlet of the freezing element.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As shown in FIG. 1 of the drawing, there is a system for freezing an incompetent formation to permit excavation, in which there are two rows 10 and 11 of spaced vertically aligned freezing elements 12. Intermediate rows 13 and 14 of freezing elements extend between the rows 10 and 11. When a low-temperature liquid is circulated through the freezing elements 12, frozen barriers are produced along the rows 10, 11, 13 and 14, allowing excavation through the formation within the rectangular pattern defined by these rows. As shown also in the schematic illustration of FIG. 3, refrigerated brine for this purpose is supplied by a refrigeration plant 15, circulated by a pump 16 through a manifold 17 to the freezing elements 12 and returned to the refrigeration plant through a second manifold 18.

Each freezing element 12, as seen in FIG. 4, includes an elongated enclosed outer tubular member 19, within which is a smaller central tubular member 20. The latter member has an open bottom end 21. A line 22, which may be controlled by a valve 23, extends from the supply manifold 17 to the upper end of the central tubular member 20. An additional line 24, in which similarly there may be a valve 25, connects the return manifold 18 to the upper end portion of the outer tubular

member 19 of the freezing element. The entrance 26 to the line 24 is above the surface 27 of the ground and immediately below the domed upper end closure 28 on the outer tubular member 19 of the freezing element.

With this construction, brine flows from the supply manifold 17 through the connecting lines 22 to the central tubular members 19 of the various freezing elements in the rows 10, 11, 13 and 14. The brine circulates through the central tubular member 20 to its bottom end 21, where it discharges into the interior of the outer tubular member 19 and then flows upwardly. The brine exhausts from the freezing elements through the connecting lines 24 to the return manifold 18. The flow of the brine through the freezing elements 12 causes the adjacent formation to be frozen along the rows 10, 11, 13 and 14.

As the brine passes through the pump 16, the resulting foaming and cavitation cause a substantial quantity of air to become entrained with the liquid. This air tends to separate from the liquid at the locations of the freezing elements 12. A portion of this air collects at the inlet to the inside tubes 20 of the freezing elements. An even greater quantity accumulates at the domed upper end closures 28 of the outer tubular members 19, adjacent the freezing tube outlets where the pressure is lower and the air can more readily escape from the liquid. Unless it is removed, the quantity of air will build up over a period of time. The lower level of the air will move downwardly in the freezing elements as the air volume increases, ultimately obstructing the inlets and outlets of the freezing elements. When this occurs, either the flow of brine will be reduced or it may be blocked entirely. Therefore, the functioning of the freezing elements will be impaired or it will cease altogether.

The automatic bleeding arrangement of this invention includes a small line 31, which conveniently may be a length of ⅜-inch copper tubing, connected to the upper domed end 28 of each of the outer tubular members 19 of the freezing elements above the entrance 26 to the outlet line 24. A valve 32 is provided in each of the lines 31. The lines 31 connect to a manifold 33, considerably smaller than the supply and return manifolds 17 and 18, which is positioned above the upper ends of the freezing elements 12. The manifold 33 is arranged in a pattern such that it is adjacent the freezing elements 12 in all the rows 10, 11, 13 and 14. Consequently, the manifold 33 includes sections parallel to the rows 10 and 11 of the freezing elements, with branches of the manifold extending inwardly from either end of the interconnecting rows 13 and 14 (see FIG. 1). The manifold 33 also connects through a line 34 to the inlet of a pump 35. A line 36 extends from the pump outlet to the inlet side of the refrigeration plant 15. The manifold 33 is arranged so that it inclines downwardly toward the pump, as may be seen in FIG. 5. Any liquid in the manifold 33 will flow by gravity to the inlet of the pump 35.

At spaced locations, such as at the corners of the rectangular pattern of rows 10, 11, 13 and 14 illustrated in FIG. 1, are air vent traps 38. Additional air vent traps 38 are spaced along the return line 36 from the pump 35 to the refrigeration plant 15. The air vent traps 38, as may be seen in FIG. 4, are elevated above the manifold 33 at the ends of riser pipes 39. The air vent traps 38 are of conventional construction, each defining an internal chamber 40, as may be seen in FIG. 6. Within the chamber 40 is a float 41, which is at the end of an arm 42 pivotally mounted on a pin 43. A valve element 44 having a conical end is carried by the arm 42 between the float 41 and the pivot pin 43. The valve member 44 engages a valve seat to close off the outlet opening 45 at the upper portion of the chamber 40 when the float 41 is in a raised position. If the float 41 drops, however, the arm 42 is pivoted clockwise in the illustration of FIG. 6, thereby shifting the valve member 44 away from its seat so that the outlet 45 is opened.

There is an additional bleed manifold 47, which is similar to the manifold 33, inclining downwardly toward the pump 35 to which it connects through the line 34. Small bleed lines 48 extend upwardly from the upper ends of the inner tubular members 20 of the freezing elements and connect to the manifold 47. Valves 49 are located in the bleed lines 48. Additional air vent traps 38 are located above the manifold 47 at the upper ends of risers 50.

Two independent bleeding systems are used because the pressure is somewhat higher at the inlet to the freezing element than it is at the outlet. By using separate manifolds, both the inlet and outlet of the freezing element may be bled of air without producing a bypass flow between the inlet bleed and the outlet bleed.

In use of this arrangement, the valves 32 and 49 are opened slightly to allow a flow of fluid through the bleed lines 31 and 48 to the manifolds 33 and 47, respectively. This draws off air from the circulating brine, together with minor quantities of brine, to enter the manifolds 33 and 47. The air enters the traps 38, where it separates fully from the brine and is discharged to the atmosphere. The brine flows downwardly to the pump 35, where it is returned through the line 36 to the brine supply for recirculation in the system.

The effect of the air bleed from the freezing elements 12 may be seen in FIG. 7, which illustrates the zone at the freezing element outlet. As shown, air 52 entrained in the brine 53, which collects at the upper domed end of the outer tubular element 19, is permitted to flow outwardly through the line 31 when the valve 32 is opened. This continually exhausts the air from the upper end of the tubular member 19, so that the opening 26 for the brine return line 24 never becomes obstructed.

As a practical matter, it is virtually impossible to bleed off the air from the freezing elements 12 in an adequate quantity without at the same time removing a minor quantity of the brine. In other words, if the valve 32 is not opened sufficiently to allow some brine flow through the bleed line 31, an insufficient amount of air will be exhausted from the interior of the freezing element and, over a period of time, an accumulation of air will block the access of the brine to the return line 24. Consequently, the valve 32 is opened sufficiently to bleed a small amount of brine from the freezing element along with the air. This valve setting is obtained readily through observation of the bleed line 31. The valve 32 is opened to just the degree where a thin layer of frost 54 appears on the line 31. The presence of this frost coating indicates that the flow of fluid through the bleed line 31 is adequate to assure that the proper amount of air is being removed. The valve 32 is set so that only a light frost layer 54 is produced, which occurs when the brine flow is relatively small.

This valve setting procedure may be used irrespective of variations in brine temperatures. Typically, the brine will be at around −10° F at the freezing element, but it may be somewhat above or below that temperature under some conditions. In any event, if the bleed line valve is set so that the frost layer appears, the flow through the bleed line will be satisfactory.

The bleeding arrangement and valve setting for the valves 49 in the lines 48 are similar to those described above.

The air contained in the manifolds 33 and 47, together with some of the brine, flows upwardly through the riser pipes 39 and 50, respectively, to the air vent traps 38. The air in the chamber 40 leaves the liquid and occupies the upper portion of the chamber 40. When a sufficient quantity of air has collected above the level of the liquid brine in the chamber 40, it forces the level of the brine downwardly. This permits the float 41 to drop, thereby opening the outlet passage 45. The air above the liquid then escapes from the trap. After the venting of the air in this manner, the pressure in the chamber 40 drops and the liquid is permitted to rise again, thereby elevating the float 41 and causing the valve member 44 to engage its seat. Thus, the air vent traps 38 periodically allow quantities of air to escape to the atmosphere.

While the air is vented from the traps, the liquid remaining in the manifolds 33 and 47 flows downwardly to the pump 35 to be returned to the refrigeration plant 15.

The air bleed system of this invention, therefore, provides for the continual automatic removal of air from the freeze pipes and the venting of this air to the atmosphere. Once the valves 32 and 49 are set, no further attention is needed. There is complete assurance, through the use of this system, that all of the freezing elements are in operation, with full refrigeration being provided throughout the length of each row 10, 11, 13 and 14 as the system is illustrated. All this is accomplished without loss of brine, as the small amount bled from the freezing elements is returned to the brine supply source.

The foregoing detailed description is to be clearly understood as given by way of illustration and example only, the spirit and scope of this invention being limited solely by the appended claims.

What is claimed:

1. In combination with a plurality of spaced fluid-transmitting members received in an unstable earth formation, a source of refrigerated liquid containing entrapped air, and means for circulating said liquid and air from said source to said members and back to said source for freezing said unstable formation, a device for removing said air from said liquid comprising

bleed means connected to each of said members for removing a quantity of fluid therefrom,

return means connecting said bleed means and said source of refrigerated liquid,

flow control means for controlling the amount of flow through said bleed means so as to provide a continuous flow therethrough,

and air vent means connected to said return means for receiving at least a portion of said air from said return means and discharging the same.

2. A device as recited in claim 1 in which said members include locations where said air leaves said liquid and accumulates, said bleed means being connected to said members at said locations.

3. A device as recited in claim 1 in which said flow control means allow the continuous flow of both said liquid and said air through said bleed means.

4. A device as recited in claim 3 in which said continuous flow of said liquid is sufficient to produce a relatively thin layer of frost on said bleed means.

5. A device as recited in claim 1 in which

said fluid-transmitting members are generally vertical,

each of said fluid-transmitting members includes an outer enclosed tubular member, and an inner tubular member having an open bottom end,

said circulating means including connections adjacent the upper end of each of said inner tubular members for conducting fluid to said inner tubular members, and connections adjacent the upper ends of said outer tubular members for conducting fluid back to said source,

said bleed means including first bleed lines communicating with said inner tubular members adjacent said upper ends thereof, and second bleed lines communicating with said outer tubular members adjacent said upper ends of said outer tubular members.

6. A device as recited in claim 5 in which said return means includes a first manifold, said first bleed lines being connected to said first manifold, and a second manifold, said second bleed lines being connected to said second manifold.

7. In combination with a fluid-transmitting means adapted for association with an incompetent earth formation for effecting freezing thereof, and a source of refrigerated liquid containing entrapped air for circulation through said fluid-transmitting means, a device for removing said air comprising

a bleed line means connected to said fluid-transmitting means for removing a quantity of said liquid and air from said fluid-transmitting means,

return means connecting said bleed line means to said source of refrigerated liquid,

said return means being at a higher elevation than the elevation of said fluid-transmitting means,

flow control means in said bleed line means for causing a continuous flow of said liquid and air through said bleed line means,

a pump connected to said return means for pumping said liquid to said source of said liquid,

said pump being at a lower elevation than said return means for permitting said liquid to flow to said pump by gravity,

and at least one air vent trap connected to said return means,

said air vent trap being at an elevation above said return means for receiving air therefrom and venting said air to atmosphere.

8. In combination with a freezing system for incompetent earth formations, said system including a plurality of tubular freezing elements, a source of refrigerated liquid containing entrapped air, and means for circulating said liquid and entrapped air through said freezing elements, a device for removing said air from said liquid comprising

at least one bleed line connected to each of said freezing elements,

a manifold,

said bleed lines being connected to said manifold,

said manifold being at a higher elevation than the elevations of said freezing elements,

flow control means in each of said bleed lines,

a pump having an inlet and an outlet,

said pump inlet being at a lower elevation than said elevation of said manifold,

means connecting said manifold to said inlet for conducting liquid from said manifold to said pump,

means connecting said outlet to said source of refrigerated liquid for conducting liquid from said pump to said source,

and air vent trap means for collecting and releasing said air,

said air vent trap means being connected to said manifold,

said air vent trap means being at an elevation higher than said elevation of said manifold.

9. In combination with a freezing system for incompetent earth formations, said system including a plurality of tubular freezing elements extending downwardly into said formation, a source of refrigerated liquid containing entrapped air, supply means connecting said source to said freezing elements for conducting said liquid thereto, return means connecting said elements to said source for returning said liquid to said source, each of said freezing elements including a zone where said air normally disassociates from said liquid and obstructs the circulation of said liquid through said element, a device for removing said air comprising

a bleed line connected to each of said freezing elements adjacent said zone,

a valve in each of said bleed lines for controlling the flow therethrough,

a manifold,

each of said bleed lines being connected to said manifold,

said manifold being at an elevation higher than the elevations of said freezing elements,

a pump having an inlet and an outlet,

said inlet being lower than said elevation of said manifold,

said manifold sloping downwardly and being connected to said inlet,

whereby liquid in said manifold flows by gravity to said inlet,

means connecting said outlet to said source,

and vent means connected to said manifold,

said vent means including

a chamber above said manifold,

means connecting said manifold and said chamber,

an outlet means for said chamber,

and a float valve in said chamber for controlling said outlet means,

said float valve being operable to open said outlet in response to the presence of a predetermined amount of air in said chamber for thereby venting such air to the atmosphere.

10. A device as recited in claim 9 in which said valves control the flow through said bleed lines such that both air and a quantity of liquid flow through said bleed lines.

11. A device as recited in claim 10 in which said valves control the flow through said bleed lines such that it is sufficient to produce a relatively thin layer of frost on the exteriors of said bleed lines.

12. A device as recited in claim 11 in which

each of said freezing elements includes

an outer enclosed tubular member,

and an inner tubular member within said outer tubular member and spaced from the wall thereof,

said inner tubular member having an open bottom portion

said supply means being connected to said inner tubular member for conducting said liquid through said inner tubular member to discharge into said outer tubular member at said bottom portion of said inner tubular member,

said return means being connected to the upper end of said outer tubular member,

said bleed lines being connected to said outer tubular members adjacent said connection of said return means.

13. A device as recited in claim 12 in which said bleed line is connected to said outer tubular member above said connection of said return means.

14. A device as recited in claim 13 including

an additional bleed line connected to the upper end of each of said inner tubular members,

a valve in each of said additional bleed lines for controlling the flow therethrough,

and an additional manifold,

said additional bleed lines being connected to said additional manifold,

said additional manifold being at an elevation higher than the elevations of said freezing elements,

said additional manifold sloping downwardly and being connected to said inlet of said pump.

* * * * *