Fig. 8

[Diagram of a cross-sectional view of a structure with labeled components such as 60, 61, 62, 63, 64, 65, 66, 70, and 10.]
MEANS FOR MAINTAINING PERMA-FROST FOUNDATIONS

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This application is a continuation-in-part of my abandoned application, Serial No. 86,217, filed January 31, 1961.

This invention relates to means for maintaining an improved permafrost foundation system, and to various configurations of the system. More particularly, it relates to what has herein been designated as a "thermo-valve foundation system" that is based on a novel means of establishing and maintaining a permafrost layer.

More specifically, the present system employs as one of its characterizing elements, a sealed hollow tubular vessel containing a liquid of low boiling point, which vessel, upon being so disposed as to have an above ground portion thereof subjected to below freezing temperatures, will effect a transfer of heat away from the buried end portion thereof thus making it possible to accomplish the following results:

1. The freezing of unfrozen foundation material in the bearing portion of the foundation;
2. Lowering of the average annual temperature of the foundation material;
3. Increasing the structural stability and strength of the foundation material;
4. Decreasing the water permeability of the foundation material;
5. Lowering the cost of accelerated foundation construction on marginal permafrost and;
6. Reducing or eliminating the maintenance cost of additional sub-grade cooling where required.

Further objects and advantages of the invention reside in the details of construction of its parts and in the mode of use of the systems as will hereinafter be fully described.

In accomplishing the above mentioned and other objects of the invention, I have provided the improved details of construction, the preferred forms of which are illustrated in the accompanying drawings, wherein:

FIG. 1 is a longitudinal sectional view of a thermo-valve piling as installed in a foundation construction.

FIG. 2 is a sectional view, similar to that of FIG. 1 but showing an adaptation of the present thermo-valve principle to a "post and pad type foundation."

FIG. 3 is a vertical cross-sectional view illustrating an application of the present thermo-valve principle for a thawing operation as applied to a roadway in a permafrost area.

FIG. 4 is a view, similar to that of FIG. 3, showing use of the present system when the heat absorption area must be higher than the condensation area.

FIG. 5 is a sectional view illustrating use of the present thermo-valve on grade construction.

FIG. 6 is a sectional view illustrating employment of a "condensation trap" in connection with the present system.

FIG. 7 is a sectional view illustrating use of the present system for stabilizing a subgrade.

FIG. 8 is a sectional view illustrating use of a thermo-valve for maintaining a permanently frozen condition in arctic and sub-arctic areas.

Referring now in detail to the drawings:

Before giving detailed descriptions of the several views of the drawings, it will here be explained that the addition of liquid propane, carbon dioxide, or other liquids of low boiling point to a suitable enclosed container used as herein described is the characterizing feature of the thermo-valve foundation system of this invention as set forth in the following specification.

In the several views illustrating the present system and various uses, the thermo-valve is designated in its entirety by reference character T. It comprises a rather elongated tubular container, closed and sealed at its opposite ends, and partially filled with a selected liquid of low boiling point. The container, preferably, is cylindrical in form and is equipped with suitable high pressure, quick disconnect fittings, or other connections for introducing the fillings, not herein shown, of the normally used type for the application of additional liquid to the container.

Liquid level in the container may be controlled by various means but preferably by the use of a small bleed valve with a section of tubing extended into and downwardly in the vessel to a point at which it is desired to establish the liquid level therein, for example, at the level as has been illustrated in FIG. 1 by the dash line 1—1.

The use of the present thermo-valve takes into consideration the following fundamental physical principles:

1. The vapor density of any given substance is lighter than its liquid state.
2. The vapor pressure of a substance is increased with an increase in temperature.
3. The vapor density of a substance at constant volume decreases with a reduction in temperature.

Referencing now in detail to the several views of the drawings.

In FIG. 1, I have illustrated the installation of a thermo-valve piling in a permafrost area. The piling comprises a cylindrically tubular container 10 closed and sealed at its opposite ends by end plates 11—11, and enclosing a predetermined amount of the selected suitable liquid 12 therein. This thermo-valve unit may be either a foundation piling or a separate pipe attached to the foundation piling. The top level of the liquid 12 is here shown to be substantially at the top of the permafrost area as designated by horizontal dash line 1—1. For satisfactory operation, there should be no internal restriction in the container 10 to hinder the return of the vapor condensed to the elevation of desired heat extraction of the pile or cylinder, the containers must be so constructed as to prevent leakage or rupture at the particular saturated vapor pressure induced by the selected fluid at the maximum operating temperature.

The temperature of the system will be controlled by the rate of heat flow to the liquid 12 at the lower end of the piling, the rate of gas flow within the tube, the rate of condensation at the upper end of the piling, and the rate of heat dissipating to the air, ground and portions of the structures adjoining the thermo-valve.

In FIG. 1 of the drawings, the tubular piling 10 is shown as being vertically disposed within a well 15 formed in the permafrost area 16, and resting at its lower end on a gravel pad 18 and surrounded up to the top of the permafrost by a gravel filling 20. Above the permafrost 1—1 the cylinder 10 is surrounded by an earth filling 21. Above the grade, the container 10 is surrounded by an exposed frame designated by numeral 23.

The application of this unit thermo-valve foundation in an area results in the following: During periods of subfreezing temperatures vapor in upper end of its closed vessel is condensed on the column surface by the conduction of heat away from the column in the upper soil layers and connecting structural members and by radiation and convection from the exposed portion of the column. The condensed vapor returns to the lower end by gravity. The condensation of the vapor reduces the pressure in the column and permits boiling and evaporation of the liquid at the bottom whenever its temperature is greater than the condensation temperature. The evaporation of the liquid causes a lowering of its temperature with a resultant inflow of heat from the ad-
joining permafrost. The result of the operation is the freezing of unfrozen soil and/or the lowering of the permafrost temperature with a consequent increase in its strength of adhesion (added freeze strength) to the foundation.

In FIG. 2, I have illustrated the present thermo-valve unit as applied to a post and pad type foundation. In this view, the tubular container is substantially like that of FIG. 1 in its application to a permafrost area and the same reference numerals have been given thereto to designate like parts. In this view the metal tubular container 10 is shown to be vertically disposed in a well 15 and to project above ground surface level, and to be equipped at its lower end with a metal base plate 25 that is secured to the container by means of a plurality of metal fillets 26; the plate 25 rests upon a gravel pad 27. The plate 25 is shown as being of substantially greater diameter than the container 10 and equipped with a plywood lower face 28, or a face of other material of low heat conductivity, with breather holes 29 formed therethrough in order to permit vapor migration to take place freely to the colder upper surface of the plate 25. The plywood face 28, reduces the heat transfer to the lower surface of plate 25 so that, during the time of greatest cooling, the condensation of the water vapor to ice will occur on the upper surface and thereby eliminate icing of the lower surface.

Cooling of the footing subgrade results from a combination of thermal conduction, evaporation, and/or sublimation of moisture in the subgrade. It is indicated in FIG. 2 by arrows which show direction of heat flow, that heat is extracted from the pad and surrounding permafrost area by the container 10 and its liquid 12. Saturated vapor rises into the upper end portion of the container and its heat is extracted by the surrounding earth or construction materials above the permafrost area. The result is a cooler foundation area and warmer area above the permafrost line. Radiation and convection in the areas above the permafrost line results in condensation of the saturated vapor and the return of condensate to the supply of liquid in the lower end of the container. In this installation, the conduction of heat from the permafrost area is facilitated by the metal base plate 25 and the fillets 26.

FIG. 3 is a view illustrating use of the present system embodying pipes 40 buried beneath an embankment slab 41 and terminating outside the structural subgrade to provide cooling of the subgrade to maintain or to help maintain a permafrost foundation. By reversing the slope, it would be possible to similarly prevent freezing in the subgrade beneath refrigerated structures in normally thawed areas.

In FIG. 6, I have illustrated the addition of a condensation trap 45 to the basic thermo-valve system of FIG. 1 in order to hold the liquid in a position where it can serve as a high heat source for short periods of time with a continuous but lower capacity heat source serving to elevate the vapors to the trap area during periods of lower temperature in the trap area. As illustrated in FIG. 6, the system provides heat from thermal or air convection to thaw a vertical drain system in areas where drainage would be required concurrently with thawing weather.

The thermo-valve and thermo-valve trap systems are applicable to some types of vertical and sand drains and dry well construction. The thermo-valve trap is also applicable to a particular configuration of thaw line construction in which the primary heat source must be kept elevated above the heat dissipating area as illustrated in FIG. 4. Reference numerals applied in FIG. 6 designate parts that correspond to similarly identified parts in FIG. 1.

In FIG. 7, has been illustrated an application of the present system for the stabilizing of subgrade by its use for creating permafrost with imbedded thermo-valve pipes 50—50 for use as a stronger and more impervious core for earth dams, coffer dams, and temporary retaining walls of the character illustrated. The thermo-valve pipes herein are illustrated as equipped with heat absorption fins 51 about their upper end portions.

FIG. 8 illustrates the use of the present thermo-valve system for maintaining a permanently frozen condition in foundation soil in arctic and subarctic areas, when said thermo-valve penetrates a heat source area such as, for example, a body of sea water.

In this view, the tubular metal housing of the thermo-valve is designated by reference numeral 10 which is shown to be vertically disposed and to penetrate at its lower end in permanently frozen soil designated at 60. Above this frozen soil, the housing passes through tide water 61 which has high and low tide elevations designated, respectively, by the lines 62 and 63. At its top end the tubular housing is closed by a plate 64 on which a frame structure is supported. This plate is equipped at its underside with a plurality of concentric fins 65 to expedite or facilitate heat loss through the head plate and structural framing supporting thereon.

In that area of the housing that is between the elevations of high and low tide lines, fins 66 of annular formation are applied horizontally to the housing walls. These fins are inwardly and downwardly dished to divert condensation from surface tube to prevent re-evaporation of condensate from above tidal area during high tide periods, but to permit condensation at low tides during cold weather.

Applied to the interior wall surface of the housing, along that portion which extends from the permanently frozen ground to low tide level, is a suitable insulation 68 which has for its purpose to prevent re-evaporation of condensate from the heat source area.

In that lower end portion of the housing which is contained in the frozen soil, a bank or succession of annular fins 70 that divert the rising vapors away from the heat transfer from soil to the selected liquid 12 that is contained in the lower end portion of the thermo-valve. Below the bank of fins 70 is a series of concentric fins 72 designed to permit a higher rate of heat transfer through the base plate in a position that will permit a minimum of vapor insulation of the heat absorption surface.

It is to be understood that the present thermo-valve system may be put to various uses other than herein illustrated, one of which could be its employment in cables and wires for towers and the like, where it is important that the anchoring soil be retained in its frozen condition. The manner of installing the thermo-valve as an anchoring device would vary with conditions and requirements of its use as such, but its mode of operation would be in accordance with the disclosures of the specification.

What I claim as new is:

1. A permafrost foundation system comprising a sealed, elongated, hollow container supported in a permafrost area and extending upwardly therefrom; said container being partially filled with a body of liquid of low boiling point from which vapor will be caused to rise and condense in an upper heat dissipating portion of the container during periods of below freezing temperature, thereby lowering vapor pressure in the container, with incident evaporation of liquid in its lower portion with a consequent reduction in temperature that allows flow from the surrounding soil to the container, thereby reducing temperature of the permafrost with an increase of its strength and stability; the body of liquid in the container being restricted from boiling during periods that the upper portion of the container is subjected to above freezing temperatures, thereby maintaining, a small portion of vapor in the container not convect to the lower portion of the container because of its lower density, thus resulting in a discon-
tinuance of thermal activity during periods of above freezing temperatures; said container being composed of metal and being closed at its lower end by a metal disc of substantially greater diameter than the diameter of the container; a disc of low conductivity applied to the lower surface of the metal disc; both of said discs having a plurality of aligned holes formed therein at greater radii from the axial center of the container than the tubular container, to permit water vapor to pass upwardly through said holes to the upper colder surface of the disc and thereby eliminate detrimental icing of the lower surface of the disc.

2. A permafrost foundation system comprising a sealed, elongated, tubular container supported in a permafrost area and extending upwardly therefrom, said container being partially filled with a body of liquid of low boiling point from which a vapor will be caused to rise and condense in an upper heat dissipating portion of the container during periods of below freezing temperatures, thereby lowering vapor pressure in the container with incident evaporation of liquid in its lower portion with a consequent reduction in temperature that allows heat to flow from the surrounding soil to the container, thereby reducing temperature of the permafrost with an incident increase of its strength and stability, the body of liquid of the container being restricted from boiling during periods that the upper portion of the container is subjected to above freezing temperatures by the super heat condition, a small portion of vapor in the container will not convect to the lower portion of the container because of its lower density thus resulting in a discontinuance of thermal activity during periods of above freezing temperatures; said container being composed of metal and being closed at its lower end by a metal disc of substantially greater diameter than the diameter of the container, a disc of lower conductivity applied to a lower face of the metal disk, both discs having a plurality of aligned holes formed therein at greater radii from the center than the tubular container, to permit water vapor to pass upwardly through said holes to the upper, colder surface of the disc and thereby eliminate detrimental icing of the lower surface of the disc.

3. The system of claim 2 wherein said container is positioned in a tidal water area and said container is provided on the inside by concentric rings whereby liquid condensate is diverted away from its walls to prevent its reevaporation within the tidal height when in contact with the tidal waters but yet to permit condensation between these rings to effect the refreezing of the underwater foundation during low tidal levels when the tidal water is not in contact with that portion of the container.

4. A permafrost foundation system including a device for maintaining a permafrost layer of earth properly frozen wherein the permafrost layer includes a surface layer having an upper surface exposed to the atmosphere, said device comprising an elongated, generally vertically extending body, said body including a sealed chamber extending from a lower end portion to an upper end portion thereof and said upper portion extending into the atmosphere above said upper surface, a central portion extending through said surface layer and a lower portion extending into said permafrost area below said surface layer, the lower portion of said chamber being filled with a liquid whose vapors will condense below the thawing temperature of said permafrost layer, the remainder of said chamber being filled with the vapors of said liquid, heat dissipating means on said upper portion capable of dissipating heat from said vapors to atmosphere when the temperature of the atmosphere is below the thawing temperature of said permafrost layer whereby said vapors will condense and flow into said lower portion and again absorb heat from said permafrost layer and cause said liquid to vaporize and a layer of gravel completely surrounding said lower portion and spacing said lower portion from said permafrost layer.

5. A permafrost foundation system as defined in claim 4 wherein said liquid is selected from the group consisting of carbon dioxide and propane.

References Cited by the Examiner

FOREIGN PATENTS

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