

[54] NOVEL CONSTRUCTIONS AND METHODS

[72] Inventor: **Thomas P. Dougan**, Corona Del Mar, Calif.

[73] Assignee: **The Upjohn Company**, Kalamazoo, Mich.

[22] Filed: **Aug. 5, 1970**

[21] Appl. No.: **61,356**

[52] U.S. Cl. **61/36, 52/169, 94/4**

[51] Int. Cl. **E02d 3/00**

[58] Field of Search **61/36, 36 A, 50, 35; 161/160; 260/215; 94/7, 4, 10; 166/DIG. 1; 52/169, 742**

[56] References Cited

UNITED STATES PATENTS

3,279,334	10/1966	Quartararo	94/7
3,250,188	5/1966	Leonards	94/10 X
3,429,085	2/1969	Stillman, Jr.	161/160 UX
2,420,833	5/1947	Monroe	94/4 X
3,385,001	5/1968	Bordner	49/490 X

3,135,097	6/1964	Scheinberg.....	61/36 A X
3,298,146	1/1967	Retz	61/36 R X
3,400,085	9/1968	Kujawa et al.....	260/2.5 AJ
3,561,175	2/1971	Best et al.	61/50 X

Primary Examiner—David J. Williamowsky

Assistant Examiner—Philip C. Kannan

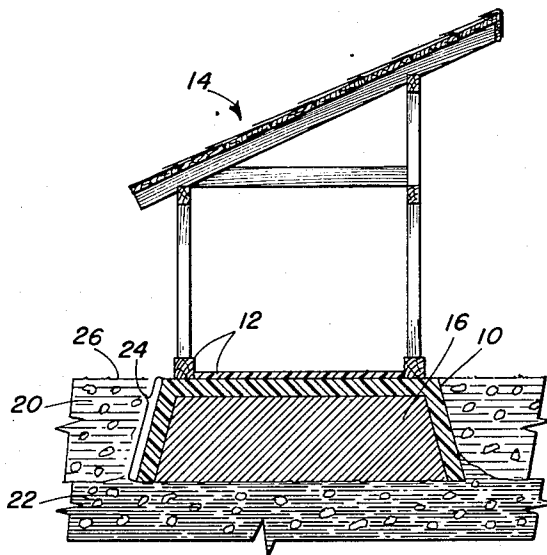
Attorney—John Kekich, Denis A. Firth and Joseph T. Eisele

[57]

ABSTRACT

An improved construction is disclosed which utilizes a frozen surface as a support means. The improvement comprises a thermal barrier interposed between the base portion of the construction and the frozen surface. The thermal barrier functions to stabilize the frozen surface by prevention of its thawing, thus maintaining support capacity. The thermal barrier can be of rigid plastic foam materials, such as polyurethane foam or a composite of said rigid plastic foams with other thermal insulating materials. The advantages of the improved construction include ease of construction, lower cost, and production of a stable construction upon normally unstable surfaces.

18 Claims, 4 Drawing Figures



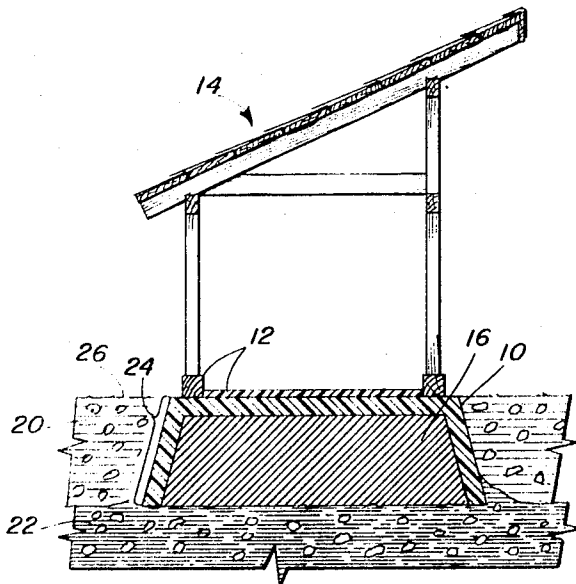


Fig. 1

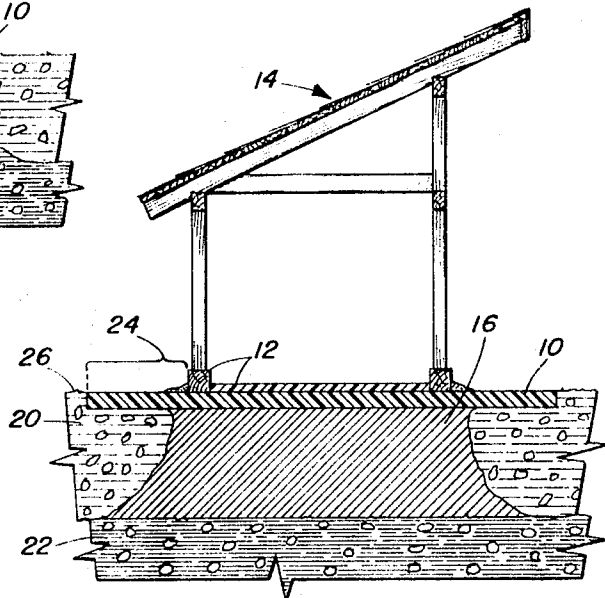


Fig. 2

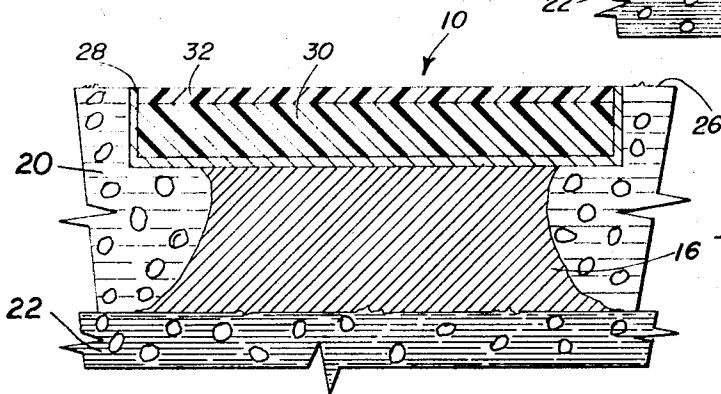


Fig. 3

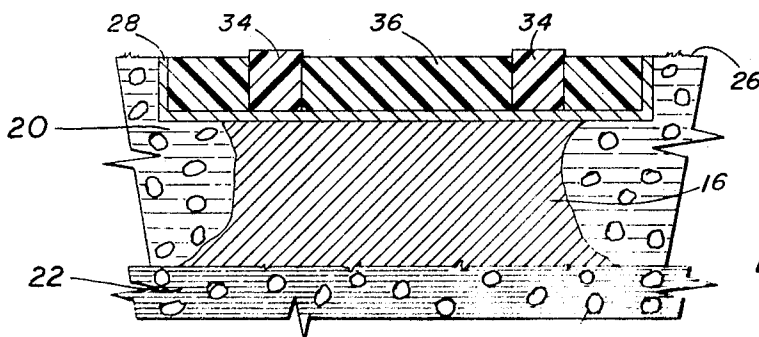


Fig. 4

INVENTOR,
THOMAS P. DOUGAN

BY *James A. Little*
Agent

Joseph A. ...
Attorney

NOVEL CONSTRUCTIONS AND METHODS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to constructions, and to load supporting foundations. More particularly it is concerned with the improvement of a supported construction wherein a frozen surface is the support means.

2. Prior Art

Load supporting foundations placed within or upon frozen surfaces subject to periodic thawing, are prone to damage from stress forces of expansion and contraction exerted upon the foundation during alternating freeze-thaw cycles. In addition, although the underlying frozen surface may offer excellent support and stability during the period when it is frozen, these desirable characteristics are lost when the support surface thaws. As a result, partial or complete settling of the superstructure occurs, usually with severe structural damage.

Previous methods of maintaining a stable structure upon frozen surfaces include excavating several feet of moisture containing surface material and replacing it with frost free materials such as moisture free gravel. The method is not entirely reliable since this material tends to shift and displace and is not always readily available in the location in which it is to be used.

In U.S. Pat. No. 3,135,097 (Scheinberg) a complex concrete foundation is constructed in soils subject to alternate thawing and freezing. A freezable liquid is contained in compartments within the foundation walls and maintained in a frozen state. The foundation, in effect, is a refrigeration unit.

In U.S. Pat. No. 3,279,334 (Quartararo), a method is disclosed for supporting roadways upon surfaces which periodically freeze and thaw. A layer of insulation is placed directly beneath the foundation so as to prevent the conduction of heat through the foundation, thus preserving a layer of frozen material as support for the foundation. Sheet piling has to be inserted around the edges of the foundation to prevent drainage of water, etc. in the frozen layer of soil.

I have found that it is possible to stabilize frozen surfaces of the earth which otherwise would periodically thaw, so that they can be used as a permanent foundation or support for constructions. This can be accomplished in the remotest of localities with a minimum of imported materials. A further advantage of my invention lies in the relatively heavy loads which can be supported, at minimal costs.

SUMMARY OF THE INVENTION

The invention comprises an improvement in a construction supported on a frozen surface normally subject to periodic thawing.

The improved construction comprises, in combination:
a continuous thermal barrier interposed between the base portion of said construction and said frozen surface;
said thermal barrier having a peripheral margin extending outwardly beyond the outer perimeter of said base portion;
said thermal barrier being in contact with said frozen surface;

whereby said frozen surface supporting said construction is maintained permanently frozen.

The invention also comprises methods for effecting the above described improvement and for stabilizing frozen surfaces subject to periodic thawing, which surfaces are employed to support constructions.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings,

FIG. 1 is a cross-sectional side elevation illustrating a construction incorporating a preferred embodiment of the present invention;

FIG. 2 is a cross-sectional side elevation showing an alternate construction of the invention;

FIG. 3 is a cross-sectional side elevation of a thermal barrier in accordance with the invention;

FIG. 4 is a cross-sectional side elevation showing an alternate structure of a thermal barrier in accordance with the invention.

DETAILED DESCRIPTION OF THE INVENTION

The constructions to which this invention relate include buildings, storage containers, storage platforms, pylons, power line poles, towers, conduits, machinery platforms, vehicle parks, roads, aircraft runways, causeways and like structures. The invention is particular advantageous when the load to be supported is substantial and relatively constant as in a building, a machinery platform and like structures. This type of construction is generally inflexible and subject to damage from shifting or collapse of underlying support; therefore, the support must be substantial and stable at all times.

The frozen surface supporting the above described constructions is a frozen geologic strata, and can be ice or frozen mixtures of water with soil such as gravel, rock, sand, clay, silt, peat, humus and mixtures thereof. Such frozen surfaces occur naturally in the ice covered polar regions and in the tundra and taiga regions of high latitude areas where they are more commonly referred to as "permafrost". The frozen surfaces on which the constructions of this invention are supported are not restricted to the above named geographic locations, however, but include high altitude areas where the air temperature is below 32° F. during the nights and/or days for a substantial portion of a calendar year. The term "periodic thawing" refers to the melting of said frozen surfaces cyclically, when ambient temperatures rise above the freeze point of water. Cycles may be daily or seasonal, naturally occurring or artificially created, for instance by the presence of artificial heat.

The thermal barrier employed in this invention is a mechanical shield barring the transfer of thermal energy through itself. The barrier is fabricated conveniently from rigid cellular plastic insulating foams such as polyurethane, polystyrene, polyurea, polyamide, polyisocyanurate and the like polymeric rigid foams or combinations thereof. Polyurethanes are the preferred insulating foams because of their resistance to fungus and insect damage, low moisture absorbance, low vapor permeability, low K-factor, structural strength, and ease of preparation by a variety of techniques such as pour-in-place, spray and frothing techniques. When the foam is fabricated in situ by any of these methods, suitable molds are fabricated on the site from materials such as wood, silicone rubber, aluminum and the like. When the fabrication is carried out during the period for which the surface layer is permanently frozen, said surface itself can be used as part or all of the mold.

Methods for preparing and applying the above plastic foams are so well known, and literature descriptions so abundant, as evidenced by the article "Foamed Plastics" in the Kirk-Othmer, Encyclopedia of Chemical Technology, 2nd edition, Vol. 9, pp. 847-884, that it is not necessary to provide details here. More particularly, for example, the preparation of rigid polyurethane foams and techniques of molding are detailed in the text Saunders & Frisch, Polyurethanes: Chemistry and Technology, Vol. XVI Part II, Interscience, John Wiley & Sons, 1964, pp. 193-298. Methods of spray-in-place polyurethane foam fabrication are well known, and described for example in U.S. Pat. No. 3,091,551. Although the barrier can be fabricated entirely of the named polymeric foams, composites with other insulating and/or vapor impermeable materials which add to structural strength, stability or insulative efficiency are preferred. For example, the presence of water within a cellular foam increases thermal conductivity of that foam. It is therefore preferred that the insulative efficiency of the barrier be maintained by applying a vapor impermeable material such as polyethylene film, asphalt compositions, aluminum foil or like materials to foam surfaces which are likely to be exposed to moisture, thus providing a vapor impermeable barrier. A convenient method of applying a moisture impermeable cover is by spraying-in-place a non-cel-

lular polyurethane or a very high density polyurethane foam surface layer.

Thermal insulating fillers of cork, expanded perlite, vermiculite, expanded glass, fiberglass, mineral wool and like low thermal conducting materials can be advantageously incorporated into the polymer foam thermal barriers of the invention in order to lower costs. Other fillers which serve as reflective thermal insulators, for example, aluminum flakes, opacified powders and the like, can be incorporated advantageously into the polymer foam to improve insulative efficiency of the thermal barrier. The techniques of preparing such filled foams are well known, as illustrated by the method of U.S. Pat. No. 3,225,128 for preparing a heat reflective polyurethane foam by incorporating a phosphatized aluminum flake as a filler. Other heat reflective devices such as aluminum foil, aluminum sheets, aluminized fabrics and the like can be advantageously placed in or upon the upper foam surface if desired, at selected positions, to reduce the amount of radiant thermal energy entering the barrier.

Panels of flame resistant insulative material can be incorporated into the foam surface at selected positions advantageously. For example, expanded perlite composition boards prepared by the methods referred to in U.S. Pat. No. 3,510,391, panels of cellular glass and the like, can be incorporated in the foam barrier upper surface. Such composites provide a barrier immune to hazards posed by sources of open flame such as heating units. Alternately, numerous well known methods are available for preparing fire resistant foam compositions by including fire retardants in the foam formulation; see for example U.S. Pat. Nos. 3,420,786; 3,428,577 and 3,498,937. Other methods of imparting fire retardancy to polyurethane foams are detailed in the text Saunders & Frisch, supra, at pp. 222 - 225.

Particularly useful thermal barriers are composites which comprise a rigid plastic insulating foam of a given low density and a rigid cellular insulating foam of a relatively higher density. Lower density foams (circa 2 pcf density) are more efficient thermal insulators than higher density foams, but the lower density foam usually has less structural strength. To meet specific strength requirements without sacrificing barrier efficiency, the above composites are used as the thermal barrier. The strength requirements contemplated can be divided conveniently into two types.

Firstly, the compressive strength requirements of the barrier are important because the barrier is interposed between superstructure and foundation of the construction. Generally, the load imposed by the superstructure is not evenly distributed over the major area of the thermal barrier, but is imposed more upon selected minor areas. If the load imposed crushes the barrier, insulative quality is lost at the point of collapse. The compressive strength of a given plastic foam can be determined by the method of ASTM-D-1621-59T. As stated before, an advantage in employing polyurethane foam is its structural strength. For example, a low density polyurethane foam of about 2 lbs./cu. ft. density has a low K factor and can have a compressive strength of up to about 3.5 tons per square foot. This foam provides an efficient thermal barrier and will support the average one story frame building without danger of crushing. Polyurethane foams having densities of up to 10 lbs. per cubic foot are considered here as low density, and can have compressive strengths of up to 25 tons per square foot. It is preferable however, to fabricate the thermal barrier from a polyurethane foam having a density of 2 to 5 lbs./cu. ft., to maintain a low K factor material within the barrier. Therefore, when the superstructure load is such that it will exceed the compressive strength of the thermal barrier at certain select points comprising a minor area of the barrier, a composite barrier is preferred having higher compressive strength rigid cellular foam in the major load-bearing areas, and lower strength, lower K factor material throughout the majority of the non-load-bearing areas of the barrier.

The second type of strength requirement in the thermal barriers of the invention is concerned with stability of the barrier

under conditions of abrasion, penetration, impact and like mechanical stresses and also when subjected to degradative agents such as oil, water, solvents, and the like. Methods of increasing the mechanical strength and impermeability to liquids of the thermal barrier have been discussed above and include the incorporation of various fillers and the coating of the surface of the barrier with moisture impermeable sheets or coatings. An alternative and preferred manner of imparting the desired stability to the thermal barrier is to fabricate the latter as a composite of rigid polymer foam layers of differing densities and characteristics. Illustratively, a composite of this character comprises one having an upper surface layer of very dense (10 to about 60 lbs./cu. ft. density rigid polymer foam and preferably one having an integrally formed non-cellular skin. The lower layer of the thermal barrier is a rigid polymer foam, preferably polyurethane, of up to about 10 lbs./cu. ft. density preferably 2 to 5 lbs./cu. ft. The high density surface layer is tough, vapor impermeable, and has a high impact and abrasion resistance. Further, there is sufficient body in such a dense layer to hold nail or screw fasteners, thus providing a means of securing the base portions of a construction to the thermal barrier.

The above-described composite thermal barrier structures can also serve a dual function as a floor or sub-floor for the improved construction. The high density foam can be any of the previously named polymeric foams, but again is preferably a polyurethane foam for the reasons recited before. Methods of preparing very high density polyurethane foams are well known as are methods for preparing integrally skinned polyurethane foams. See for example the following patents: U.S. Pat. No. 3,099,516; and French Pat. No. 1,559,325 which are concerned with integral skin foams and U.S. Pat. Nos. 3,400,085 and 3,467,605 concerned with high density polyurethane foams. Variations of foam density can be made chiefly by adjusting proportions of blowing agent in the foam mix as is well known to those skilled in the art (See for example Saunders and Frisch, supra). In fabricating a composite barrier by foaming-in-place techniques, the adjustments of formulation necessary to produce different densities can be made during fabrication, so that integrally formed barrier structures having layers of differing density are made in a single continuous operation.

The determination of thickness of the thermal barrier required to maintain the underlying surface frozen can be readily determined by reference to a mathematical equation given by H.S. Carslow et al., in "Conduction of Heat in Solids" Oxford Press, 1947, pp. 40-60. Practical application of the equation is demonstrated in U.S. Pat. No. 3,279,334. The equation is as follows:

$$L = 2 \times \left[\frac{k_i}{k_g} \times \frac{T_a - T_{gs}}{T_{gs} - T_g} \times \sqrt{d_g \times t} \right]$$

where:

L = Thickness of insulation in centimeters

k_i = k -factor of insulation material in cal./sec/cm.²°C./cm

k_g = k -factor of frozen ground in the same units

T_a = mean temperature of ambient air during warm spell

T_{gs} = Maximum allowable frozen surface temperature

T_g = Temperature of frozen surface during freeze period

d_g = Diffusivity of ground in cm/sec²

t = Time of warm spell in seconds.

The warm spell is defined as the average length of time during a calendar year when the temperature is above 32° F. It should be noted that in using this formula, L is a minimum thickness, and for a safety margin should be multiplied preferably by 100-200 percent. The thermal conductivities (K -factor) and diffusivity of various materials are available from various standard texts, such as "Mechanical Engineers' Handbook", by Lionel S. Marks, fourth edition, McGraw-Hill, 1941; "Architectural Graphic Standards" by Charles Ramsey and Howard Sleepee, John Wiley & Sons, 1959; "American Institute of Physics Handbook", McGraw-Hill, 1947, and

"American Society of Heating, Refrigerating, and Air-conditioning Engineers Inc. Guide," 1964-1966. In addition to these texts, ASTM standards test methods are available for determining the K-factor of insulative materials. For example, ASTM-C-177-45 details a standard method for determining the K-factor of a given polyurethane foam.

As an illustration of the required thickness of the thermal barrier it is found that a barrier constructed of polyurethane foam of a density of about 3 pcf, a K-factor of about 0.15, and a thickness of 3 to 4 inches is entirely adequate, when interposed between the base of a construction and the surface of a frozen surface normally liable to periodical thawing to a depth of about 3 feet, to maintain said frozen surface in permanently frozen condition even during warm periods of 3 to 4 months when ambient air temperatures average 60° F.

In constructing the thermal barrier on a frozen surface in accordance with the procedures discussed above, it is essential that the periphery of said barrier extend outwardly beyond the outer edges of the base of the construction which is to be supported thereon. This feature is necessary to ensure stabilization of the frozen surface beneath the construction. The minimum distance to which the periphery of the thermal barrier extends beyond the outer edges of the base of the construction supported thereon varies in accordance with a number of factors the chief of which is the extent of the periodical thawing which occurs in the surface immediately surrounding the edges of the thermal barrier. The said minimum distance required in any given location can be readily determined by trial and error.

In general said minimum distance should be at least equal to the maximum depth beneath the surface at which periodical thawing normally occurs. In any event said minimum distance is advantageously at least 3 feet even in locations in which the depth below the surface at which periodical thawing is experienced is at a minimum.

The above-described projection of the periphery of the thermal barrier beyond the edge of the supported construction serves to prevent any significant amount of thawing in the frozen surface, beneath that portion of the thermal barrier which is in contact with the base of the construction, due to lateral transmission of thermal energy from the surface areas surrounding the edges of the thermal barrier during the period in which the said surface areas are subject to thawing.

In a preferred mode of construction the portion of the thermal barrier which extends beyond the outer edge of the supported construction, is fabricated so that it projects downwardly into the strata surrounding the supported construction. Most preferably the said periphery of the thermal barrier extends downwardly into the surrounding strata to a depth at which said strata remains permanently frozen i.e. is not subject to periodical thawing. In this most preferred embodiment the thermal barrier serves to "cap" a layer of frozen surface and to maintain it in a permanently frozen state completely insulated from exposure to thermal energy from the surrounding strata or from the air above the strata.

The angle at which the periphery of the thermal barrier descends into the surrounding strata in the above embodiments is not critical. Thus the said periphery can descend vertically into the strata but preferably projects downwardly and outwardly from the outer edge of the supported construction at an angle of from about 30° to about 60° to the horizontal plane. The configuration of said periphery projecting into the surrounding strata is also not critical. Thus said periphery can be substantially planar, can be convexly or concavely arcuate in cross-section, or can descend in step-like fashion.

Once the thermal barrier has been installed on the frozen surface in any of the above-described ways and using any of the various configurations described above, the construction to be placed upon the thermal barrier can be assembled in accordance with conventional procedures commonly used in the art. As set forth above said construction can take a variety of forms and can be a residential building, a commercial or manufacturing building, warehouse, storage facility, pylon, pipe-line support, road, aircraft runway, and the like.

The improved constructions of the invention will now be further described and exemplified by reference to the various specific embodiments set forth in the drawings.

FIG. 1 is a cross-sectional side elevation of a preferred embodiment of the invention. The improved construction depicted comprises a continuous thermal barrier 10 positioned between base portions 12 of construction 14 and a supporting frozen surface 16 which is normally subject to periodic thawing but is now maintained permanently frozen by the method of the invention. Barrier 10 is in contact with supporting frozen surface 16 and functions to maintain said surface 16 permanently frozen by shielding it from sources of thermal energy. Surrounding the barrier 10 is a non-supporting frozen surface 20 which is not protected from thermal radiation and is subject to periodic thawing. Strata 22 is a sub-strata not subject to melting, such as bedrock, frozen material beyond the depth subject to thaw, or non-frozen supportive material not subject to freezing. That portion of barrier 10 extending outwardly beyond the outer perimeter of base portions 12 illustrates one form of the peripheral margin 24 of barrier 10 essential to stabilization of frozen surface 16. As shown in FIG. 1, the peripheral margin 24 projects from ground line 26 to a point within strata 22. The angle at which peripheral margin 24 descends can be up to about 90°, but is preferably between about 30°-60°.

Under some circumstances, it may not be feasible or possible to terminate the peripheral margin 24 within strata 22, for example, when suitable excavation equipment is not available or the load to be supported is relatively light. In such instances thermal barrier 10 is conveniently fabricated as shown in FIG. 2. Illustrated in FIG. 2 is a cross-sectional side elevation of a construction similar to that shown in FIG. 1, except that peripheral margin 24 of thermal barrier 10 lies on a plane approximating that of ground line 26. The distance said margin 24 extends outwardly beyond base portions 12 in this embodiment should be at least equal to the maximum depth frozen surface 20 is expected to thaw. According to this form of peripheral margin 24, frozen surface 20 underlying peripheral margin 24 will thaw during warm periods and re-freeze during cold periods. The outer edges of supporting frozen surface 16 will be far enough away from sources of thermal energy transmitted laterally beneath peripheral margin 24 so as to remain stable during warm periods. To provide a safety margin, the distance through which peripheral margin 24 extends beyond the outer edge of base portions 12 is preferably twice the maximum depth to which frozen surface 20 is expected to thaw.

The mode of erection of an improved construction in accordance with the invention can be described conveniently by reference to FIGS. 1 and 2. In the preferred construction illustrated in FIG. 1, supporting frozen surface 16 is exposed while in the frozen state and isolated from non-supporting frozen surface 20 by excavation. In the alternate construction illustrated by FIG. 2 where peripheral margin 24 is co-planar with ground line 26, it is only necessary that the proposed site be cleared and the surface to be covered by barrier 10 exposed. The thermal barrier 10 is placed in contact with and over supporting surface 16. Base portion 12 and construction 14 are erected on the barrier and excavations backfilled. Thermal barrier 10 is conveniently fabricated in-situ using conventional methods and techniques generally employed in working with the particular material. For example, sheets of plastic insulating foam may be positioned and bonded together so as to form a continuous barrier. A preferred method of fabrication when employing polyurethane foam is to foam-in-place by pour-in-place or, spray-in-place techniques, whereby the foam forming mixture is applied to frozen surface 16 and allowed to foam thereon. Such methods allow for intimate contact between barrier 10 and frozen surface 16.

These techniques of foaming in place or on site are well known, for example as detailed in the text Saunders and Frisch, supra; in relation to polyurethane foams.

Although FIGS. 1 and 2 show a barrier 10 which lies under construction 14 in one uniform structure, the barrier can also comprise composite structures, for example as shown in FIGS.

3 and 4. FIGS. 3 and 4 are cross-sectional side elevation views of composite thermal barrier structures which exemplify preferred embodiments, to meet specific needs.

In FIG. 3, thermal barrier 10 comprises a layer of vapor impermeable material 28 such as polyethylene film, aluminum foil, asphalt compositions and the like which forms a skin for plastic insulation foam core 30 which preferably has a density of up to about 10 lbs./cu. ft. The foam core 30 can be constructed by laying sheets of preformed foam together and sealing all abutting surfaces, but is preferably prepared by pouring in place, or spray applying, a foamable mixture and allowing the foam to generate in situ. A layer of relatively high density insulating foam 32 such as a polyurethane foam having a density of between about 10-60 lbs./cu. ft. is applied and is thereby bonded to lower density foam core 30. This composite structure is particularly useful when it is desired to have a tough, abrasion resistant, impermeable barrier surface. In similar manner, other insulative materials such as sheets of perlite composition board and the like can be incorporated into the foam core 30 as by placing on the surface thereof prior to applying the second layer 32, to impart special properties such as flame resistance, additional impact resistance and the like to the barrier 10.

In FIG. 4, a cross-sectional side elevation view of an alternate thermal barrier structure 10 is illustrated. A relatively high compressive strength cellular foam 34 is placed, by assembling preformed blocks of such foam or pouring a cellular foam forming mix within a portable mold upon vapor impermeable layer 28. The positions selected for the high compressive strength foam 34 correspond to points upon thermal barrier 10 which will be subjected to stress exceeding the compression strength of the remaining areas of thermal barrier 10. The barrier 10 is completed by applying a foam material 36 of lower compressive strength to the remaining barrier 10 area. This embodiment allows the use of lower strength foams having better insulative qualities in major non-load bearing portions of barrier 10, while providing a barrier which will not collapse under unusually high loads.

It should be clearly understood that the forms of the invention shown as specific embodiments in the accompanying drawings are illustrative only and are not intended to limit the scope of the invention. As will be obvious to one skilled in the art numerous variations can be made in the various specific embodiments without departing from the scope of the invention, the essential feature of which lies in the mode of construction to the thermal barrier and its relationship to the base of the supported structure and the frozen surface on which said structure is supported.

Illustratively in the case where the devices of the invention are used to support a pylon, structural steel brackets for the supporting a pipe-line and the like, having a base which makes contact with the frozen surface at a number of relatively small areas in relatively close association with each other, the thermal barrier can be interposed between the base of the construction and the frozen surface as a single continuous unit covering the entire area delineated by the various points of contact. Alternatively a separate thermal barrier can be provided in respect of each of the various points of contact. In such a mode of construction each of the thermal barriers is separately fabricated in accordance with the various requirements of the thermal barriers of the invention as described and exemplified above.

I claim:

1. In a construction supported on a frozen surface normally subject to periodic thawing, the improvement which comprises in combination;

a continuous thermal barrier interposed between the base portion of said construction and said frozen surface; said thermal barrier having a peripheral margin extending outwardly beyond the outer perimeter of said base portion a distance at least equal to the maximum depth to which periodical thawing of said frozen surface normally occurs;

said thermal barrier being in contact with said frozen surface; whereby said frozen surface supporting said construction is maintained permanently frozen.

2. The construction of claim 1 wherein said thermal barrier is a rigid cellular polyurethane.

3. The construction of claim 1 wherein the surfaces of said thermal barrier which are in contact with said frozen surface, are vapor impermeable.

4. In a construction supported on a frozen surface normally subject to periodic thawing, the improvement which comprises in combination;

a continuous thermal barrier interposed between the base portion of said construction and said frozen surface;

said thermal barrier having a peripheral margin extending outwardly beyond the outer perimeter of said base portion a distance at least equal to the maximum depth to which periodical thawing of said frozen surface normally occurs;

said thermal barrier being in contact with said frozen surface;

said thermal barrier being a composite of at least two layers of rigid cellular polymers having different densities; whereby said frozen surface supporting said construction is maintained permanently frozen.

5. A construction according to claim 4 wherein said barrier comprises a composite of; (1) a lower layer of a rigid cellular polyurethane having a density up to about 10 lbs./cu.ft. and (2) an upper layer of rigid cellular polyurethane having a density from about 10 lbs./cu. ft. to about 60 lbs./cu. ft.

6. A construction according to claim 5 wherein said barrier comprises a composite of; (1) a lower layer of a rigid cellular polyurethane having a density up to about 10 lbs./cu. ft. and (2) an upper layer of rigid cellular polyurethane having an overall density of from about 10 lbs./cu. ft. to about 60 lbs./cu. ft. said upper layer having an integrally formed non-cellular skin.

7. A construction according to claim 5 wherein the surfaces of said thermal barrier which are in contact with said frozen surface, are vapor impermeable.

8. A construction according to claim 5 wherein said peripheral margin of said thermal barrier projects downwardly through said frozen surface subject to periodic thawing to a point in the sub-strata which is not subject to periodic thawing.

9. In a construction supported on a frozen surface normally subject to periodic thawing, the improvement which comprises in combination;

a continuous thermal barrier interposed between the base portion of said construction and said frozen surface;

said thermal barrier having a peripheral margin extending outwardly beyond the outer perimeter of said base portion a distance at least equal to the maximum depth to which periodical thawing of said frozen surface normally occurs;

said thermal barrier being in contact with said frozen surface;

said thermal barrier being a composite of rigid cellular polymers having differing compressive strengths wherein the major load bearing areas of said composite thermal barrier are fabricated from rigid cellular polymer of relatively high compressive strength and the non-load bearing areas of said composite thermal barrier are fabricated from rigid cellular polymer of lower compressive strength;

whereby said frozen surface supporting said construction is maintained permanently frozen.

10. A construction according to claim 10 wherein said peripheral margin of said thermal barrier projects downwardly through said frozen surface subject to periodic thawing to a point in the sub-strata which is not subject to periodic thawing.

11. A construction according to claim 10 wherein the surfaces of said thermal barrier which are in contact with said frozen surface, are vapor impermeable.

12. A construction according to claim 10 wherein the upper layer of the composite thermal barrier forms the floor of the supported construction.

13. In a method for erecting a construction upon a frozen surface subject to periodic thawing, the improvement which comprises;

fabricating a continuous thermal barrier upon said surface while said surface is in frozen condition, whereby said frozen surface is maintained permanently frozen; and positioning the base portion of said construction upon the exposed surface of said thermal barrier so that a peripheral margin of said thermal barrier extends outwardly beyond the outer perimeter of said base portion a distance at least equal to the maximum depth to which periodical thawing of said frozen surface normally occurs.

14. A method according to claim 13 wherein the thermal barrier is fabricated by applying a rigid cellular polyurethane forming mixture upon said frozen surface, and allowing said mixture to foam in place.

15. A method according to claim 14 wherein the thermal barrier is fabricated by covering said frozen surface in the frozen state with a vapor impermeable material;

placing a rigid cellular polyurethane forming mixture upon said vapor impermeable material; and allowing said mixture to foam in place.

16. A method according to claim 14 wherein the thermal barrier is fabricated by:

covering said frozen surface in the frozen state with a vapor

impermeable material;

placing a low density rigid cellular polyurethane foam forming mixture upon said vapor impermeable material;

allowing said mixture to foam in place;

and bonding a high density polyurethane foam to the upper surface of said low density polyurethane foam.

17. A process for maintaining in the permanently frozen state a frozen surface which is normally subject to periodic thawing, which process comprising covering said surface, while in the frozen state, with a continuous layer of a thermally insulating rigid cellular polymer, the peripheral margin of said layer extending downwardly through said surface subject to periodic thawing to a point in the substrate which is not subject to periodic thawing.

18. In a construction supported on a frozen surface normally subject to periodic thawing, the improvement which comprises in combination;

a continuous thermal barrier interposed between the base portion of said construction and said frozen surface;

said thermal barrier having a peripheral margin extending outwardly beyond the outer perimeter of said base portion and projecting downward through said frozen surface subject to periodic thawing to a point in the sub-strata which is not subject to periodic thawing;

said thermal barrier being in contact with said frozen surface; whereby said frozen surface supporting said construction is maintained permanently frozen.

* * * * *

30

35

40

45

50

55

60

65

70

75

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,667,237 Dated June 6, 1972

Inventor(s) Thomas P. Dougan

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Claim 10, Column 8, line 68:

according to Claim 10 should read: according to Claim 9

Claim 11, Column 8, line 73

according to Claim 10 should read: according to Claim 9

Claim 12, Column 9, line 1:

according to Claim 10 should read: according to Claim 9

Claim 15, Column 9, line 20:

according to Claim 14 should read: according to Claim 13

Claim 16, Column 9, line 26:

according to Claim 14 should read: according to Claim 13

Signed and sealed this 6th day of February 1973.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents