United States Patent

Newton

[15] **3,703,812**

[45] **Nov. 28, 1972**

[54] **HEAVE-PROOF ARCTIC PILING**

[72] Inventor: **George R. Newton**, Tulsa, Okla.

[73] Assignee: **Amoco Production Company**

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[52] **U.S. Cl.** **61/53**, 52/170, 61/50, 61/52, 61/53.6

[51] **Int. Cl.** **E02d 5/44**

[58] **Field of Search**.....61/53, 53.6, 53.68, 36, 50, 61/52; 52/170

[56] **References Cited**

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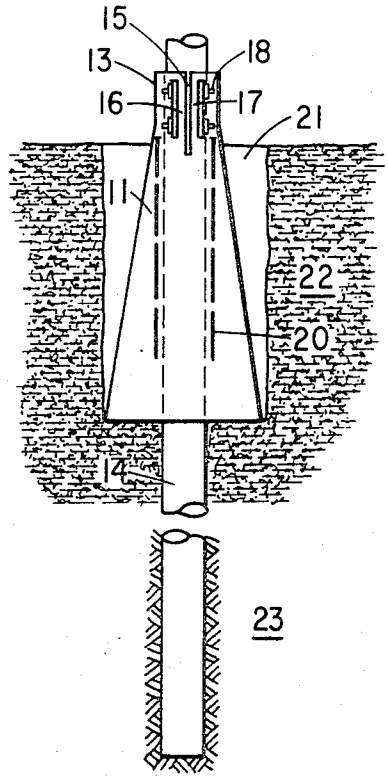
Primary Examiner—Jacob Shapiro

Attorney—Paul F. Hawley

[57] **ABSTRACT**

Piling projecting at the upper part through tundra are protected from ground movement in an upward direction due to periodic freezings and thawings of the tundra by being fixed to conically shaped collars extending down from the surface of the earth, with the base of the cone down. The conical portion thus becomes a part of the pile, mechanically speaking. If desired, the conically shaped part may be an integral part of the pile. As the liquid part of the tundra surrounding the upper part of the pile freezes, it expands radially inward against the conical surface, resulting in a downward force of sufficient magnitude to keep the pile from "heaving", i.e., moving vertically upward due to freezing effects in the ground.

3 Claims, 3 Drawing Figures



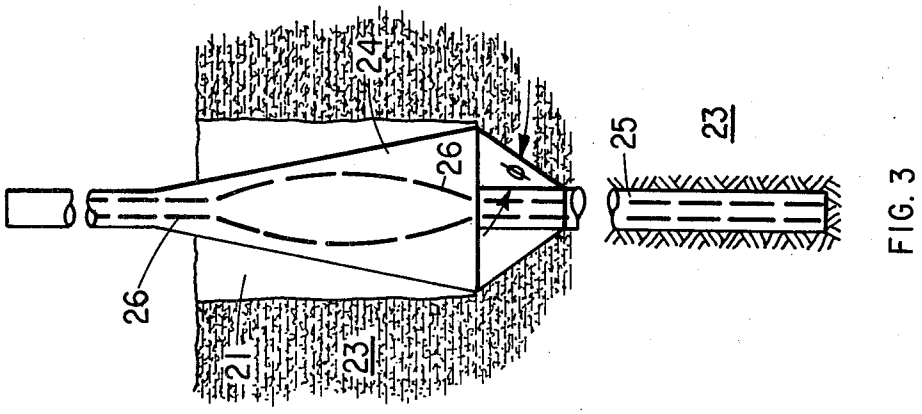


FIG. 3

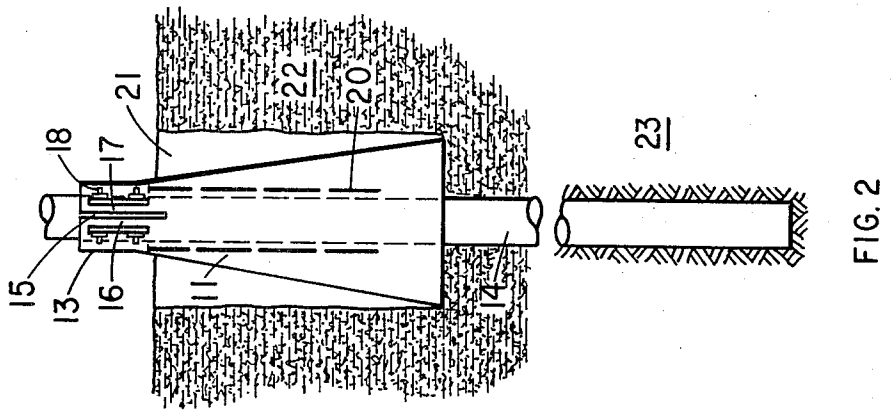


FIG. 2

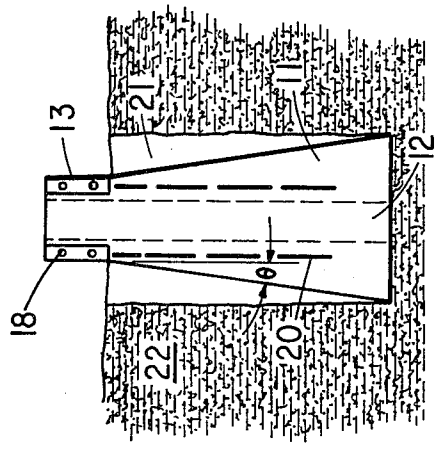


FIG. 1

INVENTOR.
GEORGE R. NEWTON
BY Paul F. Hawley
ATTORNEY

HEAVE-PROOF ARCTIC PILING

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

This invention particularly finds use in what is commonly called "tundra," that is, an unstable earth material in which there is a considerable amount of water; frequently the major portion is water. Such material is referred to as marsh in regions where there is no cyclic freezing and thawing. It is well known that during the winter months this tundra can support quite adequately any ordinary structure, following only the usual rules with respect to foundations. However, under thawing conditions the surface ice and that down a number of feet reverts to water and the resultant material has essentially no foundation properties.

In such regions it has become quite customary to locate any permanent structures, that is, those that must have a foundation the year around, on piles which are driven down into sufficiently solid subsurface formations so that an adequate foundation may result. This may be as little as of the order of 30 feet or may be 100 feet or more. The solid material may be simply permafrost, i.e., part of the marshy unstable formation which is permanently frozen, as the name indicates, or may be the ordinarily competent type of formations used for foundations in more temperate regions.

The use of such piling has revealed a problem not present in regions where the upper part of the unstable formation does not freeze, namely that in the course of freezing quite ordinarily there is a slow gradual upward movement of the entire pile. This is not always found, but it is found with sufficient regularity so that it has posed a very definite problem to construction engineers interested in erecting buildings in arctic regions. This movement is sometimes called "heaving."

2. Description of the Prior Art

A few rather scattered attempts to combat this movement have been mentioned in the literature. In "Foundations of Structures in Cold Regions," by F. J. Sanger, June 1969, Cold Regions Science and Engineering Monograph 111–C4, there is a statement that wood piles are commonly placed butt down to improve anchorage against heave forces arising in the freezing active zone. G. B. Pritchard commented in his discussion on "Foundations in Permafrost Areas," Permafrost International Conference, Purdue University, Nov. 11–15, 1963, page 516, that one can use concrete piers having a taper of 2 to 3 inches in 1 foot. He does not state anything with respect to the direction in which this batter or tapering occurs, i.e., whether the piles are placed large end up or down.

The Schutte U.S. Pat. No. 3,191,390 teaches that concrete columns can be poured in place. The lowest section of the column is made in the form of a conical section with the base of the cone at the bottom. The cone is located not at the surface but at the bottom. The use of such a pile has not been taught for arctic foundations in tundra. In fact, with this conical positioning, it would not prevent heaving.

SUMMARY OF THE INVENTION

I provide a pile arrangement particularly adapted for use in the tundra, that is, marshy areas which periodically freeze and thaw. The upper part of the pile, i.e., essentially that just below the surface, is either integrally or separately made up of a conical portion with the big end of the cone down. If the conical portion is separate from the rest of the pile (preferred arrangement) then this portion (called a conical collar) is clamped to the essentially cylindrical pile itself, so that the forces that are applied to one are applied to the other. The conical portion is preferably set in advance in a roughly cylindrical hole prepared in the tundra, if the ground is frozen, or is simply forced down if the tundra is unfrozen, until at least the major part of the cone is beneath the surface of the ground. Preferably it extends to the permafrost.

If a conical collar is used, it is provided with an axial hole through it, large enough to permit the pile to be driven through it (preferred arrangement) or for the cone to be threaded over the pile after it is driven, if necessary. Concrete piles, preferably reinforced concrete, can be prepared with the conical portion integral, in which case the entire pile is driven simultaneously. This arrangement is employed chiefly in regions in which the water portion of the tundra considerably exceeds the solid portion.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1 and 2 show a cross section through tundra illustrating the method of placing a conical pile collar in accordance with my invention and illustrating the resultant pile with conical portion after it has been prepared ready for the foundation. FIG. 2 is shown at right angles to FIG. 1.

FIG. 3 shows a cross section of tundra with an integral pile with conical upper portion, which has been driven into the tundra in preparing a foundation for a structure.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As mentioned above, wood, concrete, and metal piles have been all used in preparation of foundations in tundra. Generally these show a tendency to heave upon the freezing of the water portion of the tundra about the piling. This is true even though the lower portion of the pile has been set into normally quite competent subsurface formation, from the standpoints of ordinary soil engineering. I believe that this periodic heaving is the result of the liquid part of the tundra freezing, and, accordingly, expanding as it freezes about the pile. This can apply a pronounced lifting effect to the pile and tend to draw it periodically out of the earth. In addition to the squeezing action, the expansion also, I believe, causes the tundra to heave vertically upward and, because of its tight grip on the pile, carries the pile upward. Upon thawing the surface subsides leaving the pile protruding above the surface more than when originally placed.

In order to overcome this effect I provide the ordinary piling with a conically shaped portion, the large end of which is oriented down, the conical portion being buried in the tundra with the top substantially at the tundra surface. Preferably this conically shaped portion is made in what can be called a collar, i.e., is a completely detachable conically shaped member with a hole through it to accommodate the pile, and clamping means to attach it very securely to this pile.

Such a collar is shown in FIG. 1. The body 11 contains an axial hole 12 which extends completely throughout this member. At the top is a clamp 13 suitably provided with bolts 18 by which the clamp can be compressed about a pile such as pile 14 shown in FIG. 2.

The conical outer surface of the body of the conical collar is inclined outward at at least substantially a constant directorix angle θ. I prefer to bury the cone deep enough so the maximum cone diameter occurs at or below the zone of constantly frozen material (called permafrost). The cone diameter should be a maximum of at least three pile diameters or more. Thus the directorix angle θ may be as small as 3° and as large as 20° to 30°.

No particular form of clamp is required. That shown in FIGS. 1 and 2 simply consists of a metal member 13 with an axial slot 15 forming the boundary of two "lips" 16 and 17 (simple extensions of the outward surface) which are perforated at at least two points for insertion of clamping bolts 18. When these bolts are tightened the upper part of member 11 compresses about the pile 14 and is thus clamped to this pile.

The conical collar body 11 may be made integrally or metal, or it can be made of wood or of reinforced concrete with the clamping portion 13 forming an extension of numerous reinforcing rods 20 in the body 11, as in the version shown in FIG. 1. Preferably the conical portion is solid although in cases of necessity for extreme lightness, as where the conical collar must be air transported to a remote arctic region, one can form the body 11 from a conically shaped metal "skirt," a cylindrical section of pipe slightly larger than the pile diameter, and triangular shaped metal ribs radially oriented between the pipe and the skirt and welded to both, to transmit the downward force from the outer part of the skirt to the pile itself.

FIGS. 1 and 2 also illustrate a preferred method of placing the pile, including the conically shaped portion. In this embodiment, a substantially cylindrical hole 21 has been dug into the tundra 22 to a depth essentially equal to the axial length of the conical portion of the collar. Collar lengths of 10 to 15 feet frequently permit the bottom of the collar to be located in the zone of permafrost, which is desirable. The conical collar has then been lowered into this hole, with the clamp 13 still protruding above the surface for easy access to the bolts 18. The clamping bolts are, of course, loose at this point.

The pile 14 is then inserted through the hole 12 and driven by any conventional pile driving means until it is securely anchored in a competent formation, such as formation 23. Only after the pile 14 has been securely anchored in position are the clamping bolts 18 tightened down to clamp the conical collar 11 to the pile 14. This completes the simple procedure.

When temperatures below freezing solidify the liquids that have accumulated in hole 21 about the clamping collar 11, the approximately radially inward forces exerted by this freezing action apply an essentially downward force through the clamp 13 to the pile 14 and oppose any tendency of this pile to heave, or move gradually upward under freezing conditions.

It is not essential that one employ a detachably mounted collar 11. For example if metal piles are used, at times it is advantageous to dispense with the clamp 13 and simply weld the upper portion of the conical collar to the metal pile. Also, and as shown in FIG. 3, at times the entire pile and conical portion are made integral. In this particular illustration the conical portion 24 formed of reinforced concrete is integral with the cylindrical portion 25, there being preferably a plurality of steel reinforcing bars diagrammatically indicated at 26 spaced throughout both the conical portion 24 and cylindrical portion 25. In this case the procedure may simply be to form a cylindrical hole 21 and then drive the pile. If the tundra is mainly water at this point, of course there is no need to form a cylindrical cavity 21; one simply drives the entire pile which forms its own cavity 21 by the lower conical end of portion 24 forcing its way through the tundra.

While the conical collar of FIG. 1 was shown with a flat bottom, I prefer to have the bottom section another frustum of a cone inverted with respect to the upper conical part. This is shown in FIG. 3 also. The conical base should taper back at an angle ϕ of around 30° to 45°. Such arrangement is desirable whether the integral cone and pile arrangement be used as in this figure, or the conical collar shown in the first two figures be employed. Such bottom taper also helps position such a collar or cone plus pile to the proper depth. It also facilitates driving the cone (in either arrangement) with or without a pilot hole. If the solids part of the tundra is mobile and the water portion is thawed, one can frequently simply force the conical collar down into position as shown in FIG. 1 without any previous excavation.

For simplicity this specification has dealt with conical members and collars. Many of the advantages of this invention can be achieved using a pyramidal form for the section adjacent the surface of the tundra. Usually such a section, basically amounting to three or more oppositely disposed wedges with the tin edge of the wedge at the surface, is somewhat more difficult and expensive to construct and with no apparent major advantage over the shapes already discussed.

It should be understood that the essential point of this invention is the provision of a tapered body portion surrounding and connected to the pile, the top of this portion being located adjacent the top of the tundra and being in force-transmitting relationship to the pile or the like such that the expansive forces of forming ice about such tapered body portion provide a downward force substantially sufficient to overcome any tendency of the pile to heave.

I claim:

1. A tapered member for use in minimizing heave in a pile driven into periodically freezing and thawing tundra comprising

a. a tapered solid body the transverse dimensions of which gradually increase from top to bottom thereof, said body defining a central axial hole large enough for the pile to pass through, the bottom part of said tapered body decreasing abruptly to the dimensions of said central axial hole, and

b. clamping means connected to said tapered body for fixing said body in force-transmitting relationship to said pile.

2. Apparatus in accordance with claim 1 in which said tapered body forms substantially the frustum of a

cone the directorix angle of which is within the range of approximately 3° to approximately 30°, and said bottom part of said body is reverse tapered with respect to the upper portion thereof with a directorix angle substantially greater than that of said tapered body, so that axial length of said bottom part is substantially smaller than that of said tapered body.

3. Apparatus in accordance with claim 2 in which said tapered body forms substantially the frustum of a cone, the directorix angle of which is within the range of approximately 3° to approximately 30°; the maximum diameter of said tapered body being at least three times the diameter of said pile.

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