United States Patent

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[54] **ARCTIC PILES**
12 Claims, 7 Drawing Figs.

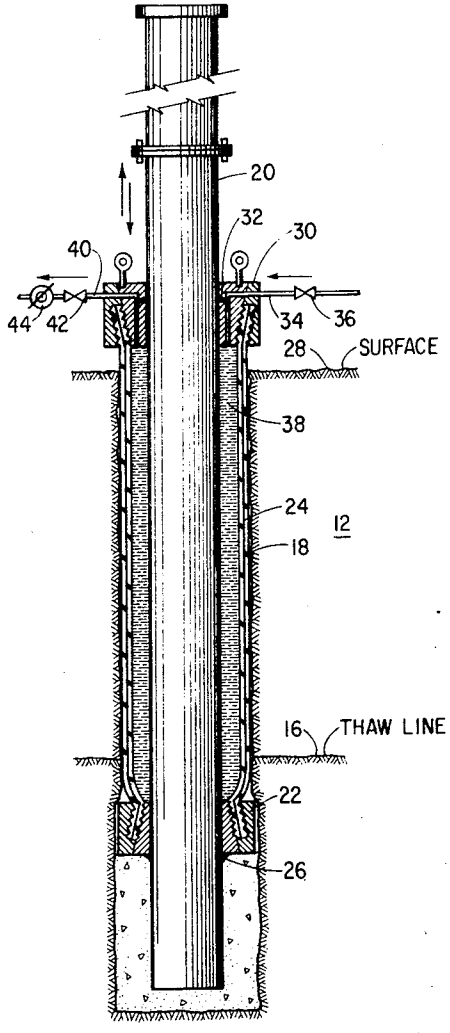
[52] **U.S. Cl.** **61/54,** 61/36, 61/1,
[51] **Int. Cl.** **E02d 5/60,** E02d 31/08
[50] **Field of Search** 61/54, 36 A–46, 46.5

[56] **References Cited**
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ABSTRACT: Piles are used quite widely in the Arctic to support buildings and structures. However, in many areas the piles are forced upwardly by the thawing and refreezing of the surrounding earth. I solve this problem of pile heaving by placing a rubberlike sleeve around the pile. The lower end of the rubber sleeve is fastened to the pile below the thaw zone. The upper end of the rubber sleeve is sealingly and slideably fitted about the pile above the surface. The cavity between the sleeve and the pile is filled with a viscous nonfreezing liquid. The heaving force which would ordinarily act on the pile now acts only on the rubber sleeve.



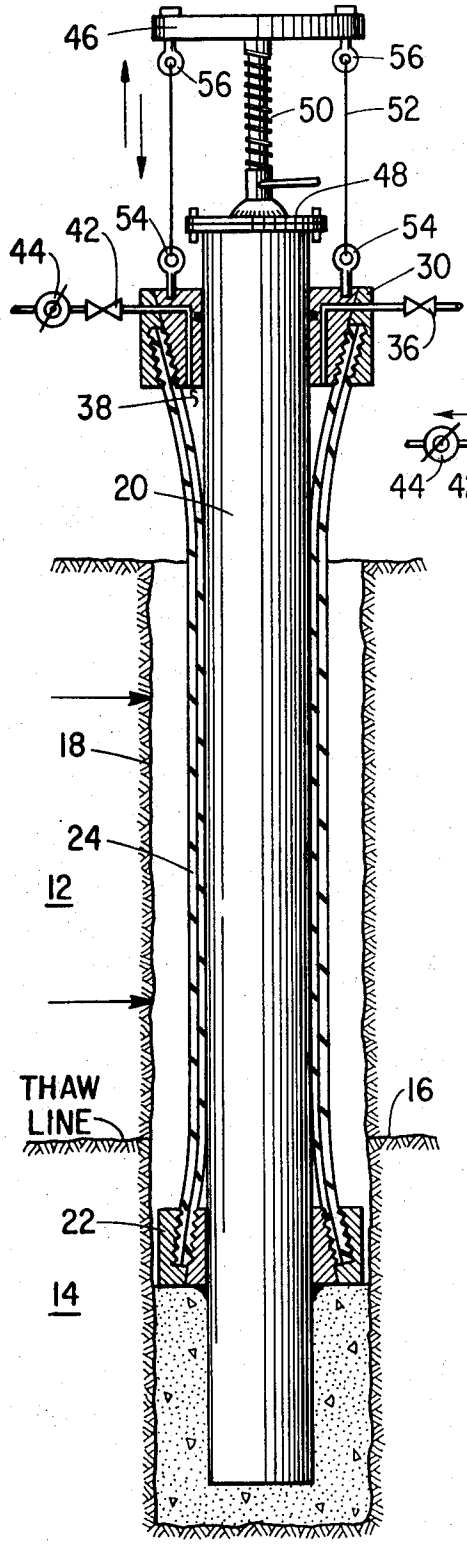


FIG. 1

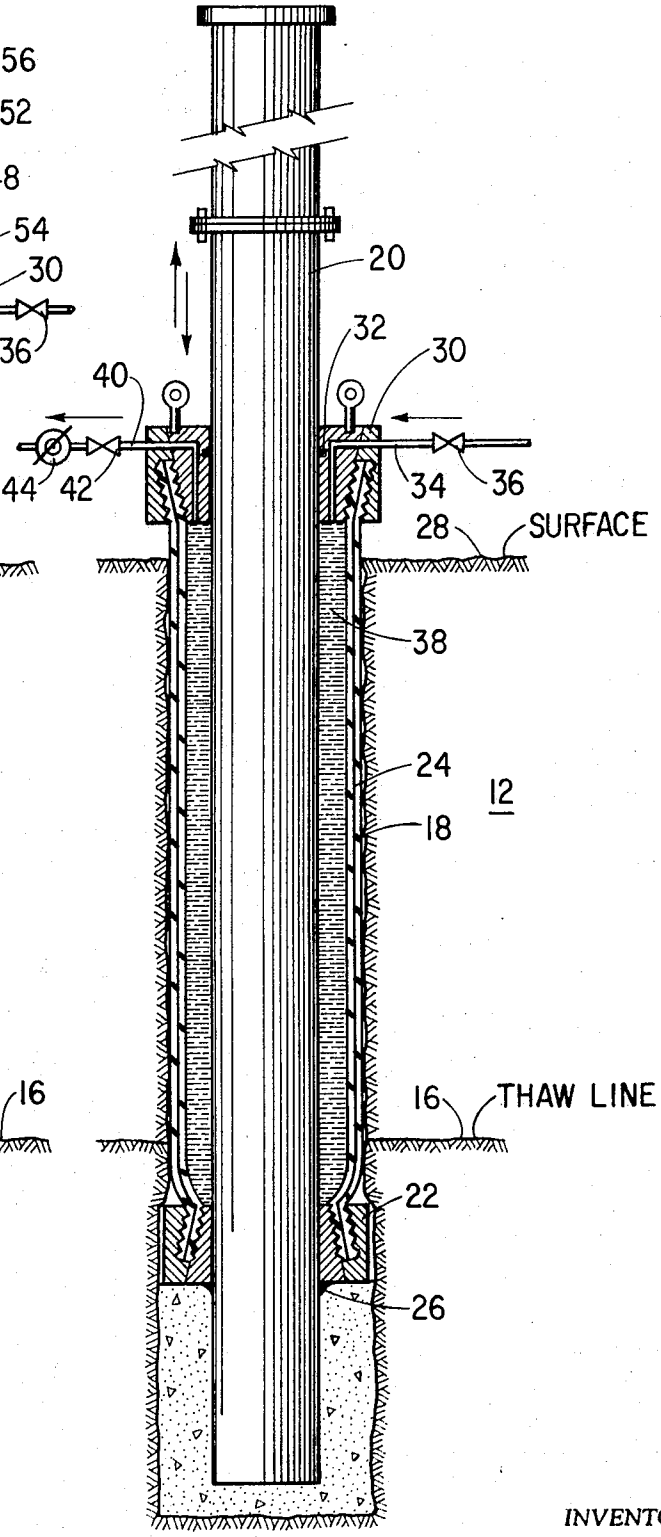
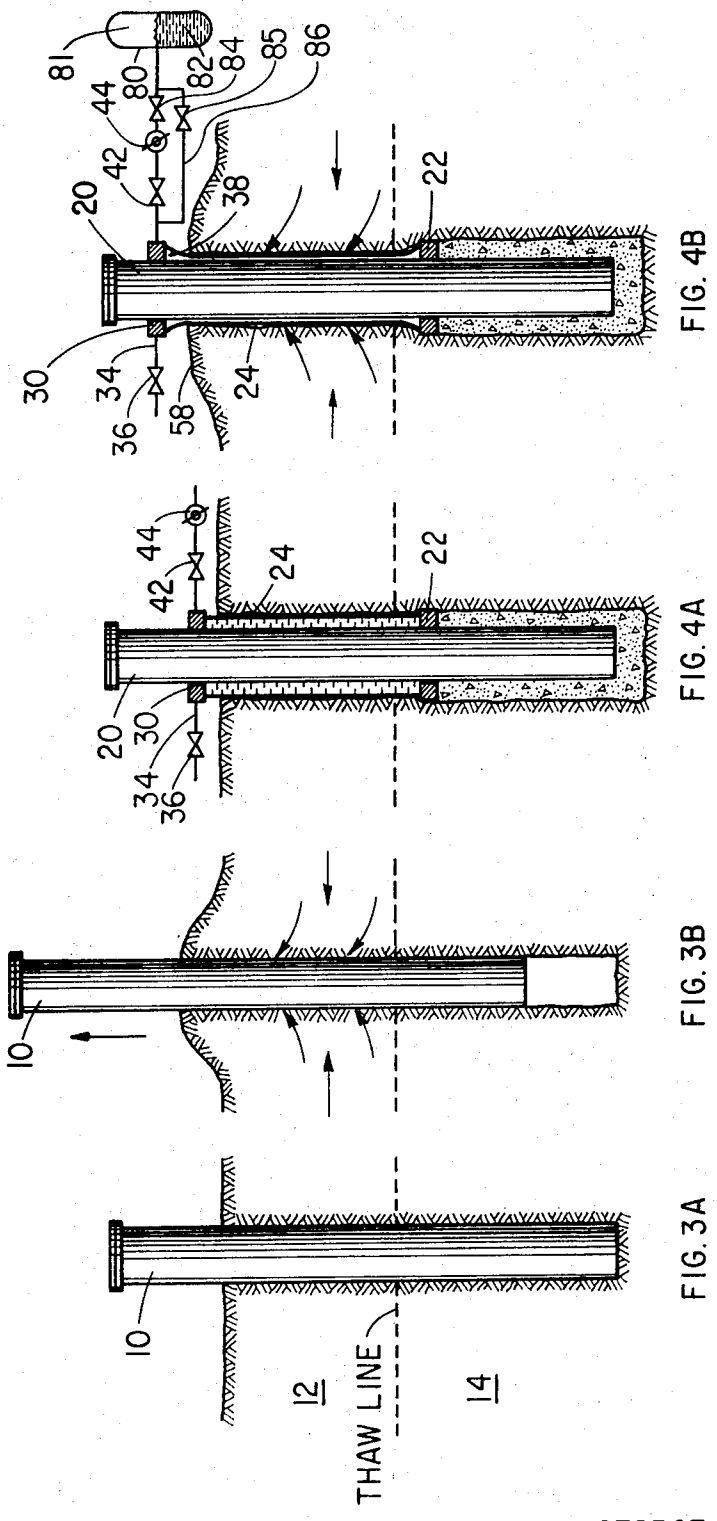


FIG. 2

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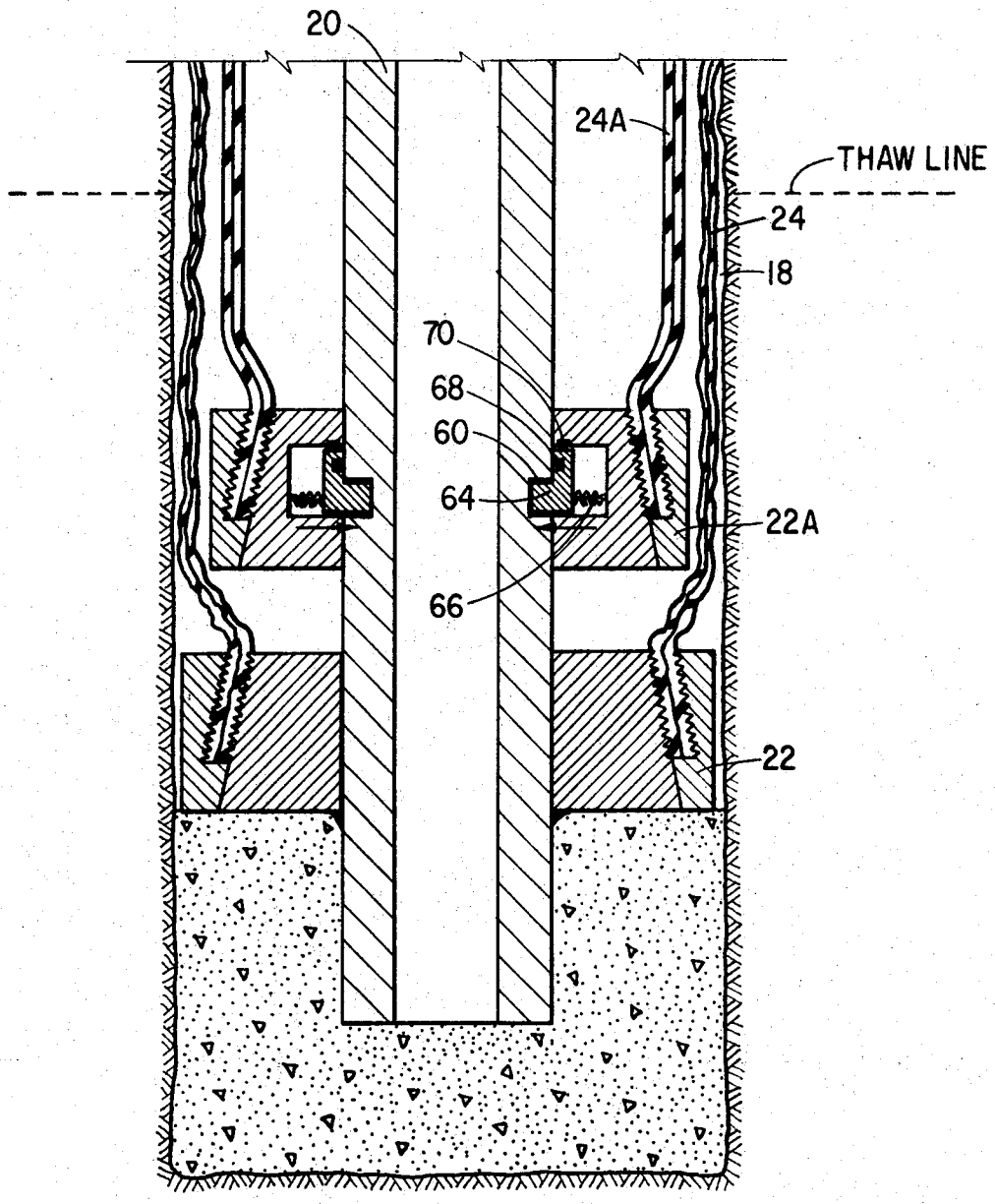


FIG. 5

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ARCTIC PILES

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to the setting of piles in a permafrost zone. It relates especially to a system of preventing the piles from heaving during the refreezing of the thawed portion of the permafrost.

Setting of the Invention

One of the more difficult areas of the world on which to support structures or buildings is in the Arctic North such as the North Slope of Alaska and Canada. There the upper layer or portion of the earth includes a frozen section known as permafrost. Permafrost consists of both a frozen matrix of water and soil and lens of ice without any soil. This zone extends in thickness from a few feet to a thousand feet or more. When this permafrost section is frozen it is a rigid mass. However, upon thawing, the thawed portion typically becomes fluid. Ordinarily this thawing, under natural conditions, only takes place to a depth of not over about 5 feet in the summer and then it refreezes in the winter. However, when it refreezes, the surface of the earth heaves. That is, it causes mounds to appear.

It is most difficult to support structures or buildings on the surface of permafrost. The most common way is to set piles deep through the permafrost thawing section and support the structures from these piles. When the permafrost refreezes in the late fall and early winter, there is a tremendous upward force exerted on the piles. These piles will then rise out of the earth, sometimes as much as 18 inches or more. This of course plays havoc with any structure the piles are supposed to support. One way which has been used reasonably successfully in overcoming this problem is to set the piles deep into the permafrost. As a rule of thumb the portion of the piles set in the permanently frozen part of the permafrost is about two to four times as long as is the thickness of that portion of the permafrost which thaws. This of course necessitates considerable expense in obtaining real long piles and in the placing of them to such a great depth. It is thus seen that there is a great need for an improved technique and system in setting piles in this permafrost area. My invention disclosed herein provides such an improved system.

BRIEF DESCRIPTION OF THE INVENTION

This is an improved pile and method of placing it. I drill a hole in the permafrost only slightly deeper than the depth to which the permafrost normally thaws. I place a "rubber" sleeve about the pile, which sleeve is slightly longer than the thickness of the portion of the permafrost which melts and refreezes. The lower end of the rubber sleeve is fixed to and sealed to the pile at a point which will be below the thaw line. The upper end of the sleeve is slideably and suitably fitted to the pile which will be at the top of the surface. The cavity between the rubber sleeve and the pile is filled with a viscous nonfreezing liquid. Any upward heaving force will be transferred to the rubber sleeve but not to the pile. THe adhesive force acts on the rubber sleeve to stretch it. This adhesive force is not transferred through the liquid to the pile. Thus the pile remains in a fixed position.

DESCRIPTION OF THE DRAWINGS

Various objects and a better understanding of the invention can be had from the following description taken in conjunction with the drawings.

FIG. 1 is a detailed drawing partly in section showing a pile modified according to my invention as it is being set in place.

FIG. 2 illustrates a pile of my invention after it has been set in place.

FIG. 3A illustrates a pile set in a normal manner.

FIG. 3B illustrates the pile of FIG. 3A after it has heaved.

FIG. 4A illustrates the pile of my invention set in the permafrost area.

FIG. 4B illustrates the pile of my invention when the surrounding permafrost has been subjected to heaving forces.

FIG. 5 illustrates a modification of the embodiment of FIGS. 1 and 2 to facilitate the replacing of the elastic sleeve.

DETAILED DESCRIPTION OF THE DISCLOSURE

Attention is first directed to FIGS. 3A and 3B which illustrate the problem which my invention solves. Shown in FIG. 3A is a pile **10** which is set into the permafrost. The permafrost consists of an upper portion **12** which thaws and melts seasonally and a lower portion **14** which is permanently frozen. In FIG. 3B, pile **10** has been forced upwardly a significant distance. Although this heaving is a common occurrence, the exact cause and mechanism of the heaving forces is not known. It is believed that the transfer of force from the freezing permafrost to the pile is by adhesion. It has also been found that if a sufficient load is placed on top of the pile that the pile will not rise. This gives some measure and indication of the adhesive force. It also gives some indication as to the anchoring which must be made available to keep the piles from rising if they are set in a conventional manner.

It is believed that a description of the piles of FIGS. **1** and **2** will be helpful before the discussion of FIGS. **4A** and **4B** is given. Shown in FIG. **1** is the upper zone **12** which seasonally thaws and refreezes and the lower zone **14** which is a permanently frozen part of the permafrost. Thaw line **16** is indicated between these two portions. A borehole **18** is drilled through the upper portion **12** into the top few feet of the permafrost below thaw line **16**. A pile **20** is placed inside the hole **18**. Near the lower end of pile **20** and below thaw line **16** is a fixed ring **22**. Rubber sleeve **24** surrounds the pile and is secured to ring **22** in a sealing connection. Ring **22** is secured to pile **20** such as by welding as indicated at **26**. The upper end of sleeve **24** extends above the surface **28** of the earth. Sleeve **24** is fastened to an upper ring member **30** which is slideably mounted about pile **20**. Seals **32** are provided between ring **30** and pile **20**. An inlet line **34** with valve **36** is provided through ring **30** and opens into the annular space **38** between the flexible sleeve **24** and pile **20**. A discharge conduit **40** having valve **42** and relief valve **44** is also provided to provide a discharge line from cavity **38** to the exterior thereof.

A viscous nonfreezing liquid is injected through valve **36** and conduit **34** into chamber **38**. A suitable liquid is napalm-thickened Arctic diesel fuel.

FIG. **1** shows how the sleeve **24** is stretched before it is placed in the borehole. The hole **18** is of course first drilled to the desired depth. Sleeve **24** is mounted about pile **20**. The lower end of sleeve **24** is connected to ring **22** which is sealed to pile **20**. The upper end of sleeve **24** is connected to upper ring **30** which is placed over or about pile **20**. If the sleeve **24** were permitted to stay in a laterally expanded position then it might be damaged when it is placed in the borehole **18**. Therefore, it is desired that the sleeve **24** hug the pile **20**. This is accomplished by opening valve **42** and allowing any entrapped air or fluid to escape from the chamber **38**. The sleeve is stretched by the jack arrangement shown in FIG. **3** causing the sleeve to reduce in diameter to the minimum allowed by pile **20**. This includes a yoke **46**, a support plate **48** on the upper end of pile **20** and a jack **50** therebetween. Annular ring **30** is connected to yoke **46** by lines **52** connected to lifting eyes **54** and **56** connected respectively to ring **30** and yoke **46**.

The annular space between the lower end of the pile **20** below ring **22** is filled with a slurry of water and soil or a water-filled grout and allowed to freeze. The rubber sleeve **24** is relaxed now by permitting upper ring **30** to move downwardly to the position shown in FIG. **2**. This is obtained by proper manipulation of jack **50**. Then the jack **50**, yoke **46** and lines **52** are removed. Now the space **38** between pile **20** and sleeve **24** is filled with a viscous nonfreezing liquid. This forces the sleeve **24** out against the borehole wall **18**. The pile is now

ready for any structure to be placed thereon as may be desired.

Attention is now directed to FIGS. 4A and 4B to show how my invention reacts to the heaving problem. Shown in FIG. 4A is pile **20** having upper ring **30** above the surface and lower ring **22** below the thaw line. Rubber sleeve **24** is therebetween. Shown in FIG. 4B the surface has heaved as shown at **58**. Any upward force created by the expanding and refreezing permafrost zone is absorbed by sleeve **24**. The upward force causes the sleeve **24** to elongate. As can be seen, upper member **30** has risen a considerable amount. This amount can be as much as up to about 18 inches and represents the approximate distances which the pile would have heaved had it not been for my invention. The upward force on rubber sleeve **24** merely causes it to elongate and no upward force is exerted on the pile itself as the liquid in chamber **38** cannot transfer the force laterally to pile **20**.

Excessive liquid pressure in the interior of sleeve **24** is relieved by pressure relief valve **44**. The outlet of relief valve **44** is connected through line **87** having valve **84** to a container **80**. Container **80** contains gas **81** and viscous liquid **82** which has been forced from the sleeve through regulator **44**. A bypass flow line **86** is provided around valves **82** and **84** and relief valve **44**. This bypass contains valve **85**. By closing valves **42** and **84** and opening valve **85**, container **80** is connected directly to the interior of sleeve **24**. When the assembly is in this condition, during freezing, a part of the viscous fluid is forced out of sleeve **24** and into container **80** compressing gas **81**. When the thaw occurs the viscous fluid **82** in the container **80** is forced back into the sleeve **24** until pressure is equalized between the container and the sleeve.

It is anticipated that in some situations after a period of time the rubber sleeve may become punctured or deteriorated to the point where it will no longer hold the viscous liquid. In such a case some means must be provided to replace the sleeve. One such means is illustrated in FIG. **5**. Shown therein is pile **20** with deteriorated sleeve **24** connected to member **22**. When the viscous fluid inside sleeve **24** is continually being lost, it shows that the sleeve **24** has deteriorated and should be replaced. The replacement should be made as soon as the deterioration is first observed. This will permit the replacement to be made before the hole **18** sloughs.

Attention will now be directed to that part of FIG. **5** which is useful for replacing the sleeve. Before pile **20** was set it was provided with a circumferential groove **62** which is at a position which after the pile is set is below the thaw line. Replacement sleeve **24A** is connected to ring **22A**. The diameter of ring **22A** is less than ring **22** so that it can fit inside sleeve **24** and slide downwardly. Ring **22A** has been modified to have a cavity **62** which holds an inwardly biased latching dog **64**. Spring **62** is provided to force latching means **64** inwardly. Seal means **68** and **70** are provided respectively between latching means **64** and the outer wall of pile **20** and the lower cavity surface **63**. The function of these seal means is to prevent fluid from above ring **22A** and inside sleeve **24A** from being forced to below ring **22A**. Inasmuch as this sealing means can be readily perfected no further detail will be given on it in this application.

As soon as the first indication of the deterioration of the sleeve **24** is made, I insert my secondary sleeve **24A**. I secure sleeve **24A** to ring **22A**. I remove upper ring **30** from about pile **20**. At the same time I secure the deteriorated sleeve **24** to a point above the surface **28**. I then connect the upper end of new sleeve **24A** to ring **30**. I then position lower ring **22A** over pile **20**. Ring **22A** is loosely fitted about pile **20** and will ordinarily slide down due to gravity. If need be, a tamping rod means (not shown) can be used to force the ring **22A** down to the desired position below the thaw line. If tamping rods are used, ring **22A** would be shoved downwardly before sleeve **24A** is secured to upper ring **30**.

While the above information has been described with a certain amount of detail other modifications can be made thereto without departing from the spirit or scope of the invention.

I claim:

1. A pile assembly for setting in a permafrost formation which comprises:
- an elongated rigid member;
- an elastic impermeable sleeve surrounding a portion of said elongated member;
- first sealing means sealing one end of said sleeve and fixed to said elongated member;
- second sealing means placed about said pile at the other end of said sleeve, said second sealing means being slideably mounted on said elongated member, the other end of said sleeve being sealingly attached to said second sealing means;
- means to inject a fluid between the said sleeve and the said elongated member.

2. A pile assembly as defined in claim **1** including an enclosed container and a flow line connecting said container to the interior of said sleeve.

3. A pile assembly as defined in claim **1** with conduit means connecting the interior of said sleeve with the exterior and a relief valve in said conduit means.

4. A pile assembly as defined in claim **3** including an enclosed container and a flow line connecting the outlet of said pressure regulator to said container.

5. A pile assembly as described in claim **3** including a viscous fluid and having a freezing point less than about 90° below zero.

6. A pile assembly as defined in claim **1** in which said second sealing means includes a first ring member, seal means between said first ring member and said pile, a conduit means extending from the interior of said sleeve through said first ring member to the exterior thereof, a valve and a pressure regulator in said conduit means.

7. A pile assembly as described in claim **1** including a latching groove in the exterior wall of said elongated member above said first sealing means.

8. A pile assembly as defined in claim **6** including a third sealing means having a second ring member of smaller diameter than said first ring member, and latching dogs biased inwardly carried by said second ring member to engage said latching groove of said elongated member;
- a replacement sleeve attached to said second ring member.

9. A pile assembly as described in claim **1** including means to place said sleeve in longitudinal tension.

10. A pile assembly as described in claim **1** in which the upper end of said elongated member includes a spool member which is detachably attached to the remaining portion of the said elongated rigid member.

11. A method of setting a pile assembly in a permafrost formation in which said pile assembly includes an elongated member, and elastic impermeable sleeve surrounding a portion of the elongated member which comprises:
- drilling a hole in said permafrost formation to a depth greater than the thaw line;
- securing the lower end of said sleeve in a fixed position about the lower end of said elongated member, the distance from said point of securing said sleeve to lower end of the elongated member being of a less dimension than the depth of the hole below said thaw line;
- placing said elongated member and said sleeve in said hole so that the lower end of said sleeve is below said thaw line;
- sealing the upper end of said sleeve in a sliding relationship with said elongated member;
- placing a viscous fluid within said sleeve.

12. A method as defined in claim **11** including the step of applying longitudinal tension to said sleeve while said pile is lowered into said hole.

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