Fig. 1

Fig. 2

Fig. 3

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This invention relates generally to a storage installation and more particularly to a below-surface storage installation having a peripheral gas-tight seal.

In large scale refinery and other industrial operations, it is often necessary to store large quantities of liquids either temporarily or for extended periods of time. Therefore, relatively large above-ground tanks have been utilized for this purpose. However, such tanks have not been found to be satisfactory for all conditions which may be encountered, and consequently improvements in storage facilities have long been sought. In the usual above-ground storage installation, it is often necessary to do extensive earth work prior to the erection of the storage tanks. Moreover, relatively elaborate foundations are necessary, as are extensive dikes which must encompass a substantially greater area than is covered by the tank itself. In certain areas of hard, irregular soil, the normal problems attendant to preparation of the area for storage tanks are greatly magnified and in some instances may jeopardize the economic feasibility of the whole project.

With the advent of the use of large quantities of low temperature liquids, the problems arising from above-ground installation have been increased. Due to the nature of these liquids, it is necessary that heat loss be maintained at a minimum; and in order to minimize this loss in the above-ground storage installation, various schemes have been tried. Among these are the securing of insulating materials around the exterior of the tanks and the use of double-walled tanks. In either case, the problems attendant to the erection and maintenance of the heat barriers have proved to be formidable.

Another problem which accompanies the storage of large quantities of low temperature liquids, that of vapor loss has long challenged the engineers and scientists. The high vapor pressures characteristic of low temperature liquids make necessary an effective seal about the storage installation to prevent the escape of vapors therefrom. In the past, numerous attempts have been made to maintain such a seal by the use of elaborate mechanical installations or, in some cases wherein below-ground storage was used, by the use of an ice cover over the storage area itself. However, due to the relatively low temperatures of the stored liquid, metallurgical problems have arisen when mechanical seals are used and, in the case of ice cover, undesirable adulteration of the stored liquid is often encountered.

An important object of this invention is to facilitate the storage of low temperature materials with minimum heat loss therefrom.

Another object of this invention is to provide a liquid storage installation which assures a permanent vapor-tight seal.

Another object of this invention is to provide an underground liquid storage installation which does not necessitate elaborate dikes.

Still another object of this invention is to provide a storage installation having a seal forming a part thereof which is readily constructed out of existing material.

A further object of this invention is to provide a storage installation which may be quickly and economically installed under adverse terrain conditions.

Yet another object of this invention is to provide a gas-tight seal utilizing a trench filled with freezable liquid.

The foregoing and other objects are accomplished in accordance with this invention by a novel storage installation which comprises a depression or excavation formed in the surface of the ground above which is disposed a foundation member. Between the periphery of the depression or excavation and the foundation member is constructed a relatively narrow trench into which is placed a quantity of liquid, such as water, which freezes above the temperature of the liquid stored in the tank. A relatively impervious roof member is secured upon the foundation and extends over the storage installation itself. Secured to the roof member at a point between the trench and the outside edge of the foundation members is a sheet of relatively impervious sealing material having one edge projecting into the liquid which is contained within the trench.

This will be better understood with reference to the accompanying drawings forming a part of this application and illustrating certain embodiments of this invention.

In the different figures of these drawings, the same reference numerals are applied to the same or corresponding parts.

In the drawings:

FIGURE 1 represents a top plan view of a storage installation having a portion of a roof member cut away to show a gas seal associated therewith; and

FIGURE 2 represents a cross-sectional view taken on line 2-2 of FIGURE 1 showing a novel sealing arrangement illustrating one embodiment of the invention.

FIGURE 3 represents a detailed representation of a portion of the structure shown in FIGURE 2 showing the position of a sealing member in relation to a liquid-filled trench.

Referring now to FIGURES 1 and 2, there is shown along the surface of the earth means for supporting a roof cover which may include a closed, continuous footing 11 which can be partially buried, as indicated in FIGURE 2, or which may be installed directly on the surface of the ground. While the footing is shown in the drawing as being of a particular shape, it is to be understood that other forms may be used. For example, pileings may be substituted for the disclosed structure, or a plurality of spot footings may be utilized. Resting upon footing 11 is a cover or roof 12 which is disclosed in the drawing as being of hemispherical cross section, although it is to be understood that the roof may be of any of several shapes well known in the art. Roof 12 is constructed of a material which is relatively impervious to vapors from the stored liquid, such as steel, rubberized canvas, plastic sheathing or other materials which will be obvious to one skilled in the art. Suitable means such as bolts, nails or other structure well known in the art may be used to maintain the roof on footing 11. Located beneath roof 12 is a depression 13 in the surface of the earth which may be excavated in any particular shape or which may be a naturally occurring irregularity in the ground. If it is desired, a quantity of sealing material 14 may be secured to the inner walls of depression 13 to prevent the escape of stored material. This sealing material may be any one of several satisfactory materials well known in the art, such as gumite, concrete or plastic sheathing, to mention a few. It is contemplated that such sealing material will not be necessary except in unconsolidated formations.

While not shown in the drawings in the interest of simplicity, it is also contemplated that a quantity of insulating material may be used between sealing material 14 and the surface of depression 13. This material may comprise felt, perlite or any of several other materials well known in the art.

A quantity of liquid 16 is placed in depression 13 for storage. This liquid may be of several types, but the present invention is particularly useful in the storage of low temperature liquids such as methane, ethane, propane,
butane, hexane, liquefied natural gas and anhydrous ammonia.

Disposed about the periphery of depression 13 is a trench 17 into which is placed a quantity of liquid 18, such as water, having a freezing point above the temperature of liquid 16 within depression 13. Trench 17 is spaced from the outer edge of depression 13 far enough to insure a rigid wall on the inside portion of trench 17 and close enough to the liquid within depression 13 to assure that liquid 18 within trench 17 will be frozen after material 16 within depression 13 has been in place for a period of time. It has been found that the distance between the outer periphery of depression 13 and trench 17 may vary from 1 to 15 feet, depending upon the size of the installation and the nature of liquid 16 within the depression. Normally, trench 17 will be spaced from 3 to 5 feet from the edge of depression 13.

A continuous sealing member 19 is secured to a portion of the lower surface of roof 12 in a gas-tight seal at a point between trench 17 and the outside edge of footing 11. This seal may be effected by a clamp 28, by adhesive material, or by other means well known in the art. In addition, member 19 may be formed of relatively rigid material such as metal sheathing or preferably of flexible material such as plastic, rubberized canvas and the like. The other edge of sealing member 19 is placed within the liquid 18 in trench 17. Although not shown in the drawings, a quantity of insulating material such as felt, perlite or the like may be disposed along the bottom of member 19. Such insulation has the advantage of protecting footings 11 from thermal fluctuations as well as preventing heat leak into the storage area.

In the use of this installation a quantity of water or other liquid which will freeze above the temperature of the liquid within depression 13 is injected into trench 17, after which the edge of sealing member 19 is placed within the trench. Subsequently, a quantity of methane or other low temperature liquid is injected into the depression 13. After a period of time the ground immediately surrounding the depression 13 becomes frozen, and the area of freezing gradually expands to include the ground surrounding trench 17. As this happens, the liquid within trench 17 will itself become frozen to insure a gas-tight seal with sealing member 19.

Because of the rigid nature of the ice formed in trench 17, gas pressures arising from the relatively high vapor pressure of liquid 16 will be greatly diminished from the installation. In addition, because of the location of trench 17, footing 11 will to some extent be insulated from the low temperatures within depression 13, and conversely liquid 16 will to some extent be protected from outside heat. In addition to the advantages to be gained by the location of the trench, other advantages are realized from the structural relationship between the trench and a flexible sealing member 19. More particularly, with the described structure, gas pressure within the installation will tend to increase the efficacy of the seal by forcing flexible sealing member 19 into closer engagement with the ground and the side of trench 17. When this occurs, blowouts of the water within the trench will be substantially precluded. Moreover, due to the flexible nature of member 19, thermal stresses arising from the relatively sudden cooling of the area will be relieved.

While particular embodiments of the invention have been described, it will be understood, of course, that the invention is not limited thereto since many modifications may be made; and it is therefore contemplated to cover by the appended claims any such modifications as fall within the true spirit and scope of the invention.

The invention having thus been described, what is claimed and desired to be secured by Letters Patent is:

1. A storage installation which comprises a reservoir formed in the ground, a cover extending over said reservoir, a trench peripherally disposed around said reservoir beneath said cover, a quantity of material within said trench, a quantity of fluid within said reservoir, said fluid being at a temperature sufficiently lower than the freeze point of the material in said trench to freeze said material and a sealing member secured to said cover on the opposite side of said trench from said reservoir, said sealing member being of sufficient flexibility to move into sealing engagement with the side of said trench opposite said reservoir under the action of super-atmospheric pressure within said reservoir, a portion of said sealing member projecting into the material within said trench.

2. The structure defined in claim 1 wherein the material in said trench is water.

3. The structure defined in claim 2 wherein the reservoir is a depression formed in the earth.

4. The structure defined in claim 3 wherein a footing for supporting said cover is provided exterior of said trench.

5. A storage installation for a liquid which comprises a depression in the earth, a quantity of fluid within said depression, a cover extending over said depression, a trench disposed under said cover along the outer periphery of said depression, a quantity of frozen, normally liquid material within said trench, said material having a freezing point also being at a temperature of the liquid within said reservoir, and a sealing member secured to said cover and projecting into the material within said trench.

6. The structure defined in claim 5 wherein a footing for supporting said cover is provided exterior of said trench.

7. The structure defined in claim 6 wherein the material in said trench is water.

8. The structure defined in claim 7 wherein said sealing member comprises a flexible sheet of relatively impervious material.

9. A process in which there is provided a reservoir, a closed continuous trench disposed around the periphery of said reservoir, a quantity of liquid within said trench, a roof overlying said reservoir and a sealing member depending from said roof and projecting into the liquid within said trench; the improvement which comprises placing a quantity of relatively low temperature material in said reservoir to freeze the liquid within said trench to effect a relatively rigid, gas-tight seal between said sealing member and said frozen liquid, said relatively low temperature material being sufficiently lower than the freeze point of the liquid in the trench whereby heat adsorption causes the liquid in the trench to freeze.

10. A process in which there is provided a depression in the ground and a roof overlying said depression, the method of forming a gas-tight seal around said depression which comprises the steps of forming a continuous closed trench entirely beneath said roof, filling said trench with water, securing one edge of a continuous, flexible sealing member to said roof on the side of said trench away from said depression, locating an edge of said member within the water in said trench and placing a quantity of relatively low temperature material in said reservoir to freeze said water to effect a relatively rigid, gas-tight seal between said sealing member and the frozen water within said trench, said relatively low temperature material being sufficiently lower than the freeze point of the water in the trench whereby heat adsorption causes the water in the trench to freeze.

11. A storage installation which comprises a depression and a cover extending on the periphery of said depression, an impervious cover extending over said depression and seated on said footing, a trench disposed between said depression and said footing, a quantity of ice within said trench, a quantity of liquid within said depression, said liquid being at a sufficiently low temperature to maintain said ice in a frozen condition, and a flexible sealing member secured to said cover on the side of said trench opposite said depression, a portion of said sealing member projecting into the ice within said trench, and another portion of said sealing member being supported between said
footing and said trench, said sealing member being of sufficient flexibility to move into sealing engagement with the side of said trench opposite said depression under the action of super-atmospheric pressure within said reservoir.  

12. A method for forming a gas-tight seal for a reservoir which comprises the steps of forming a trench adjacent said reservoir, placing a gas-tight cover over the top of said reservoir, placing a quantity of liquid in said trench, projecting a portion of a relatively impervious membrane from said cover into said liquid and placing a quantity of relatively low temperature material in said reservoir to freeze said liquid in the trench whereby a gas-tight seal is formed between said membrane and the frozen liquid within said trench.

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