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CRYOGENIC STORAGE FACILITY

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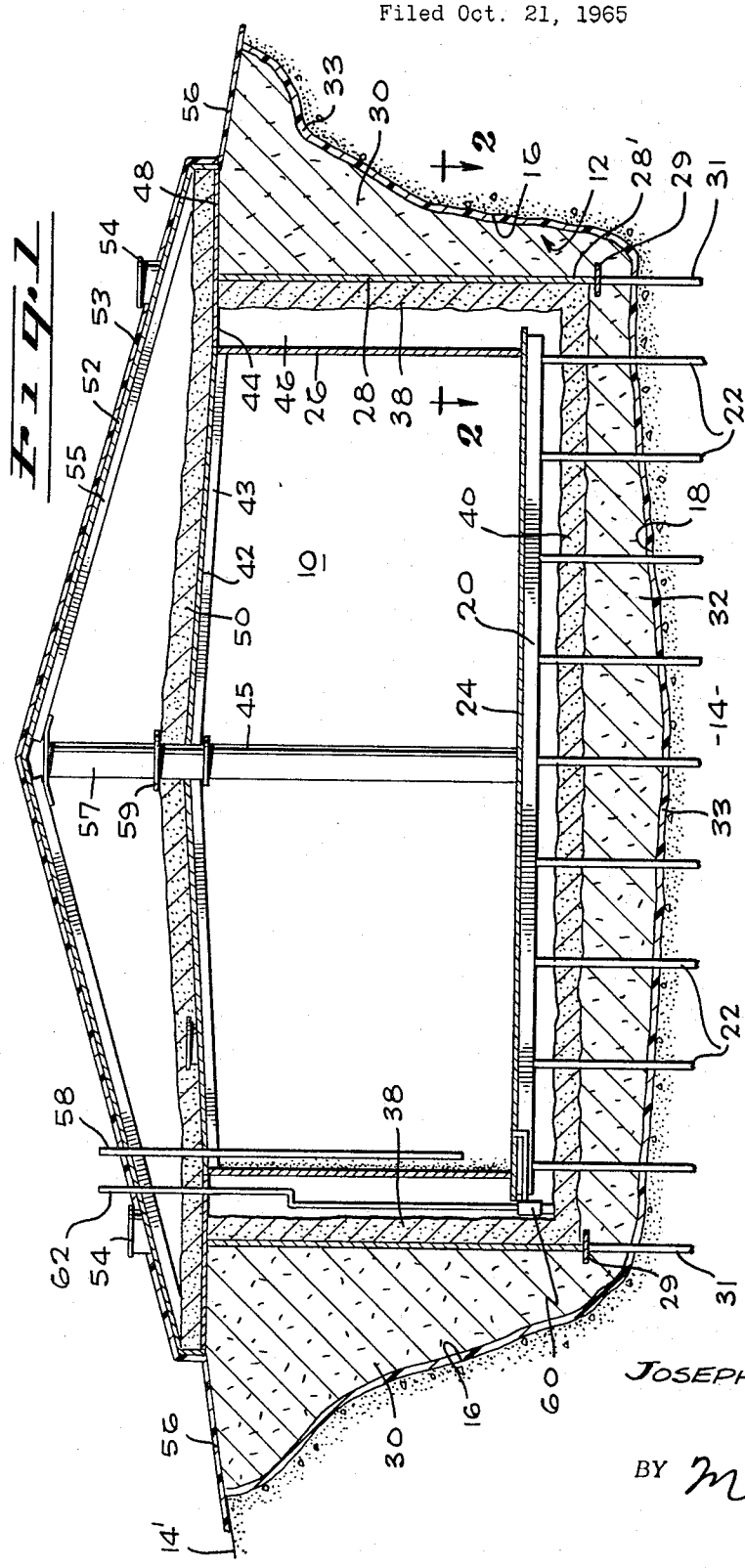


FIG. 1

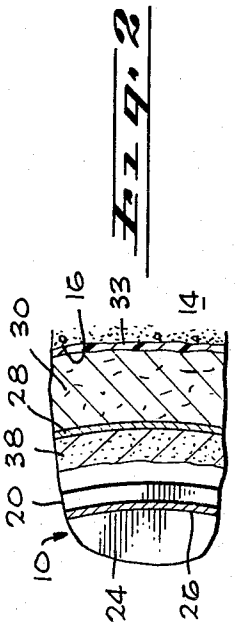


FIG. 2

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CRYOGENIC STORAGE FACILITY

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This invention relates to a storage facility especially designed for the containment and storage of cryogenic liquids, and is especially concerned with a cryogenic liquid storage facility which is disposed within the ground and which is provided with an insulation system resulting in low internal boil-off of cryogenic liquid, which eliminates danger from tank rupture and which can be constructed at relatively low cost.

Cryogenic liquid storage tanks presently in use are of two general types, namely those which are constructed above the surface of the ground and those which are constructed in the ground. These facilities are employed for the storage of very low temperature volatile liquids, such as liquid air, liquid oxygen, liquid hydrocarbons, which are often employed as refrigerants, liquid nitrogen, liquid hydrogen, liquid helium, and the like. Cryogenic liquid storage tanks which are constructed on the surface of the ground are usually in the form of a double wall vessel, the inner container holding the cryogenic liquid and the outer vessel or outer wall being spaced from the inner vessel with an insulation medium positioned between the inner tank and the outer tank. These storage facilities are subject to certain disadvantages. In the first place, the construction of such storage facilities above ground are expensive and require the employment of costly supporting structures for the tank, and in some designs heating coils are required throughout the foundations. Further, leakage of vapors to the ambient atmosphere is difficult to control, particularly when certain types of cryogenic liquids are being stored. Of particular importance any rupture of the tank will result in discharge of the cryogenic liquid to the surrounding area with resultant danger of explosion and fire where the cryogenic liquid is one which is combustible or which will form explosive mixtures with air, and also resulting in substantial economic loss

Those cryogenic liquid storage facilities which are positioned below the surface of the ground also have certain disadvantages. In these facilities, it is usually necessary before excavating the hole to first freeze the surrounding ground to allow for excavation of a hole having substantially vertical walls. This is an expensive operation which often delays the completion of the project for approximately one year. In addition, such underground storage facilities are often relatively costly, both from the standpoint of the supporting roof construction and/or the cost of prefreezing the surrounding ground. Further, in the type of underground construction presently in use, cave-ins can occur. Also, in these types of construction there is a considerable amount of initial heat leak through the walls of the tank and into the surrounding ground. Further, in these prior art underground installations there exists the problem of product contamination, and there is also little assurance of positive measurement of the amount of liquid contents in the storage facility.

The above noted disadvantages of presently constructed cyrogenic liquid storage facilities is obviated according to the invention by first providing a hole or excavation in the ground with sloping walls which permits easy excavation and will present no poblem with respect to soil heaving or ice-lensing. A suitable cryogenic liquid container or tank is placed in the excavation and is supported within the excavation on a suitable supporting structure,

preferably in the form of an elevated platform erected over the bottom of the excavation. In preferred practice, an inexpensive secondary insulation material is placed in the excavation and surrounding the cryogenic liquid container or tank, thus reducing evaporation through heat leak. A primary material preferably is provided over the top of the cryogenic liquid tank and over a portion of the excavation which is filled with the secondary insulation material, such primary insulation material also preferably being disposed between the container and the secondary insulation in the excavation. Such primary insulation protects chiefly against heat loss while providing increased efficiency through reduction or elimination of convection currents on the exterior surfaces. A vapor and water impervious barrier layer of a suitable material is placed around the upper portions of the tank and over the pit and adjacent peripheral areas to provide further protection from the weather and the elements.

The resulting underground cryogenic liquid storage system is a completely inclosed facility providing minimum heat loss from the tank to the surrounding ground. The system is particularly designed for safety of operation and since the surrounding ground after a period of time will become frozen, any leakage of cryogenic liquid, for example, due to rupture of the tank, will be contained within the frozen pit and will be completely enclosed from above by the vapor impervious barrier provided around the tank and over the pit. Further, a relatively inexpensive tank supporting structure can be provided, substantially reducing the cost of construction of the facility.

The invention will be more clearly understood by reference to the description below of a preferred embodiment of the invention taken in connection with the accompanying drawing wherein:

FIG. 1 is a sectional elevational view illustrating a cryogenic liquid storage system according to the invention principles; and

FIG. 2 is a horizontal sectional view taken on line 2—2 of FIG. 1, showing certain details of construction of the storage facility of FIG. 1.

Referring to the drawing, in constructing a cryogenic storage facility according to the invention, a cryogenic liquid storage tank or container **10** is supported within an excavation **12** of appropriate size with respect to cross sectional area and depth so as to completely receive the cryogenic tank **10**, with the top of the tank **10** approximately level with or slightly higher than the adjacent ground surface indicated at **14'**. The cryogenic liquid storage tank **10** shown in the drawing is illustrated as being of cylindrical shape and accordingly an appropriately sized excavation **12** is dug with sloping walls as indicated at **16** and a relatively level or horizontal bottom indicated at **18**, the excavation having a diameter larger than the diameter of the tank and a depth greater than the depth or height of the cryogenic storage tank **10**. The excavation **12** can be conveniently and inexpensively made by means of standard earth moving equipment, such as by bulldozers, and the slope of the wall **16** of the excavation will depend on the particular soil conditions and on the greatest economy in operation of the earth moving equipment in making the excavation. It is particularly noteworthy that such excavation does not require expensive engineering or special soil conditions with respect to providing proper support for the side walls of the excavation.

As illustrated in the drawing, the cryogenic liquid storage container **10** can be of relatively simple construction and can be a single walled metal container of standard construction for storing cryogenic liquids. It will be understood that the container **10** can be equipped with proper fittings and appurtenances (not shown) usually

employed for the operation of cryogenic storage vessels including means for providing adequate foam protection, and the like. The cryogenic liquid storage container, of course, can be of any suitable construction for storing the desired cryogenic liquid and can be of any desired shape. The container **10** is positioned in the cavity **12** and is supported therein with its bottom **24** resting on a platform or deck **20** mounted on a series of vertical supports which can be in the form of timber piling **22**, the piles being suitably and rigidly embedded in the ground **14** below the bottom **18** of the excavation.

Adjacent to but spaced from the side wall **26** of the container **10**, a retainer wall **28** is erected having a height exceeding to some extent the height of the tank wall **26**. The retainer wall **28** completely surrounds the tank **10** and extends upwardly approximately to the level of the top of tank **10** and downwardly some distance below the bottom of tank **10** as indicated at **28'** in FIG. 1. Retainer wall **28** can be formed of any suitable and preferably inexpensive material such as wood. Retainer wall **28** is supported in position on a circular base member **29** supported on piling **31** suitably embedded in the ground **14**. The retainer wall **28** can be further supported to prevent buckling by suitable reinforcing members (not shown).

The space or volume between retaining wall **28** and the sloping sides **16** of the pit or excavation **12** preferably is filled with a dry so-called secondary insulation material, which is understood herein to denote any inexpensive form of dry bulk material which has insulating properties such as sawdust, straw, and the like, as indicated at **30**. Similar secondary insulation material is also placed in a portion of the space or volume between the pit bottom **18** and the piling deck or platform **20**, as indicated at **32**. Depending upon the particular soil conditions, a water tight membrane **33** of a material impervious to water such as plastic or a pitch or asphalt layer can be placed on the walls **16** and bottom **18** of the excavation between the soil **14** and the adjacent secondary insulation indicated at **30** and **32**.

In preferred practice a primary insulation material, denoted herein as a material of high insulation characteristics and specifically designed and employed as an insulation material, such as perlite, preferably is placed, e.g., in water proof containers such as plastic bags, adjacent the inside of the retainer wall **28** in the space between it and the wall **26** of the tank, and on the surface of the secondary insulation material **32** in the space below the bottom of the tank **10**, as indicated at **38** and **40** in FIG. 1. Other suitable primary insulation materials include, for example, silica aerogel (Santocel) and diatomaceous earth. If desired, although not preferred, primary insulation can be positioned in the excavation at **30** and **32**, and secondary insulation placed adjacent the inside of the retainer wall and also just below the container, as indicated at **38** and **40**, or alternatively **30**, **32**, **38**, and **40** can be composed entirely of secondary insulation, or entirely of primary insulation.

The container **10** is provided with a roof **42** supported in suitable and in conventional fashion, e.g., on a rafter **43** supported on a central column **45**, and a cover **44** is provided to enclose the annular space **46** between the retainer wall **28** and the tank side wall **26**, and a further extension or cover **48** is provided over a portion of the lip area beyond the retainer wall **28** and over the secondary insulation material **30** adjacent the retainer wall. Container roof **42** and the covers **44** and **48** preferably are provided thereover with a thick layer of additional primary insulation material such as perlite, as indicated at **50**. If desired, although not preferred, the insulation material at **50** can be secondary insulation. The entire cryogenic liquid container **10** and the adjacent portions of the insulated pit below covers **44** and **48** are protected by a weather proof roof **52** which is preferably provided with a vapor and moisture impervious layer of material, such as pitch or asphalt, as indicated at **53**, with access

holes **54** provided in such roof. Roof **52** is supported on a rafter **55** which is centrally supported on an upper column extension **57** in turn supported on a crown plate **59** mounted on the top of column **45**. A further vapor and weather proof barrier such as a layer of rubberized asphalt or other suitable material is provided as indicated at **56**, and which extends in the form of a berm from the outer edge of the roof **52** or of cover **48**, downwardly in sloping fashion over the secondary pit insulation material **30** and over a peripheral portion of the surrounding soil **14'**. The extent of such barrier layer or pad **56** will depend in large measure on particular soil conditions.

A cryogenic liquid inlet line **58** is provided to supply the container or tank **10** with cryogenic liquid. Cryogenic liquid is removed from tank **10** as desired, via the outlet line **62**, employing a pump **60** for this purpose, or alternatively, if desired, a submerged pump (not shown).

It is accordingly seen that the cryogenic liquid tank **10** is suitably insulated to provide minimum heat leak to the adjacent ground **14** and to the ambient atmosphere above the tank by the system of insulation provided in the pit or excavation between the tank and the ground and between the top of the tank and the adjacent pit portions. After the cryogenic liquid has been stored in tank **10** for a period, the surrounding soil **14** adjacent to the excavation will become frozen, and the attainment of this condition will further tend to reduce heat leak from the tank **10**.

The cryogenic liquid storage system of the invention has a number of advantages and improvements over prior art systems. Thus, in view of the unique insulation concepts of the invention, substantially less loss of cryogenic vapors is experienced. Heat leak can be controlled readily by the particular design of insulation according to the invention, so that there is no necessity for excess energy loss where a predetermined amount of vaporization of cryogenic liquid is desired. The system is particularly designed for safe operation and for ease in fire prevention, and the frozen earth adjacent the secondary insulation **30** and **32** in the excavation will contain any cryogenic fluid which is discharged in the event of any rupture of the submerged storage tank. Further, such contingencies as noted above are minimized since the system design provides a free standing tank not exposed to any external load, reducing the danger of structural failure and tank rupture.

A particular advantage of the invention system is that the tank can be placed in any type of soil and no prefreezing of the ground adjacent to the excavation prior to installation of the tank is required, which freezing operation in conventional underground cryogenic storage installations may require from several months to a year before construction of the underground facility can be commenced. The invention storage system on the other hand can be rapidly constructed and less initial heat loss is experienced. The positive enclosure over the storage tank and excavation excludes possible contamination and permits definite quality and quantity control of the stored cryogenic liquid at all times. The entire composite system of tank, excavation and insulation is effectively protected from external weather elements by a vapor impervious barrier, and the entire system is well drained of surface water. During excavation and until freezing takes place, underground water can be eliminated or controlled by means of well points.

It will be understood that various modifications and adaptations of the invention can be made by those skilled in the art without departing from the spirit of the invention, and accordingly the invention is not to be taken as limited except by the scope of the appended claims.

I claim:

1. A cryogenic liquid storage facility which comprises an excavation, a container for a cryogenic fluid, said container having a bottom and a side wall, means supporting the bottom of said container in said excavation, with the

side wall and bottom of said container spaced from the adjacent walls and surfaces of said excavation, a non-rigid first insulation material in the space between said container side wall and the adjacent walls of said excavation, said side wall being otherwise essentially unsupported, said insulation material also disposed on the bottom of said excavation and below said container, and a second insulation material positioned over said container and over at least a portion of said excavation.

2. A cryogenic liquid storage facility as defined in claim 1, including a retainer wall positioned in said excavation about said container, said retainer wall being spaced from the adjacent wall of said container and from the adjacent walls of said excavation, said first insulation material filling the space between said retainer wall and the adjacent walls of said excavation, said second insulation material positioned over said container and over the annular space between said container and said retainer wall.

3. A cryogenic liquid storage facility as defined in claim 1, said first insulation material being a secondary insulation material and said second insulation material being a primary insulation material.

4. A cryogenic liquid storage facility as defined in claim 2, including insulation material disposed between said retainer wall and the adjacent wall of said container and also between said insulation material in the bottom of said excavation, and the bottom of said container.

5. A cryogenic liquid storage facility as defined in claim 2, said first insulation material being a secondary insulation material and said second insulation material being a primary insulation material, and including a primary insulation material disposed between said retainer wall and the adjacent wall of said container and also between said secondary insulation material in the bottom of said excavation, and the bottom of said container.

6. A cryogenic liquid storage facility as defined in claim 3, including a primary insulation material placed over said secondary insulation material in the peripheral area of said excavation just beyond said retainer wall.

7. A cryogenic liquid storage facility as defined in claim 2, said first insulation material being a secondary insulation material and said second insulation material being a primary insulation material, and including a primary insulation material disposed between said retainer wall and the adjacent wall of said container and also between said secondary insulation material in the bottom of said excavation, and the bottom of said container, and a primary insulation material placed over said secondary insulation material in the peripheral area of said excavation just beyond said retainer wall.

8. A cryogenic liquid storage facility as defined in claim 1, including a vapor impermeable barrier layer positioned over said first insulation material in the peripheral area of said excavation, and covering said area at least to the outer periphery of said excavation.

9. A cryogenic liquid storage facility as defined in claim 1, including a water impervious organic layer between the soil and the adjacent insulation in said excavation.

10. A cryogenic liquid storage facility which comprises an excavation having sloping walls, a container for a cryogenic fluid, a deck for supporting said container, pilings supporting said deck and embedded in the ground at the bottom of said excavation, said deck being positioned above the bottom of said excavation, said container mounted on said deck within said excavation, the upper portion of said container being approximately at the level of the ground adjacent said excavation, a retainer wall positioned in said excavation and surrounding said container, said retainer wall being spaced from the adjacent wall of said container and from the adjacent sloping wall of said excavation, said retainer wall having a height somewhat greater than the height of said container and extending downward a distance below said container and extending upward approximately to the level of the top of said container, a secondary insulation material filling the space between said retainer wall and the adjacent wall of said excavation, said secondary insulation material also disposed on the bottom of said excavation and partially filling the space below said container, a primary insulation material disposed adjacent said retainer wall and between said wall and the adjacent wall of said container, and also disposed between said secondary insulation material at the bottom of said excavation and said deck, a cover over said container, a cover over the annular space between said container and said retainer wall and extending over the adjacent lip of said excavation beyond said retainer wall, a primary insulation material positioned over said covers, and covering said container, said annular space and the peripheral area just beyond said retainer wall, a roof positioned over said covers and over said primary insulation material thereon, and a vapor impermeable barrier layer positioned over said secondary insulation in the peripheral area beyond said last mentioned cover, and overlying said peripheral area and said secondary insulation in said excavation.

11. A cryogenic liquid storage facility as defined in claim 10, said secondary insulation material disposed on the bottom of said excavation partially filling the space below said container approximately up to the lower edge of said retainer wall, and including a weather proof barrier layer over said roof, said vapor impermeable barrier layer positioned over said secondary insulation in the peripheral area beyond said roof slopping downwardly and covering said peripheral area and said secondary insulation and also the soil adjacent the periphery of said excavation.

12. A cryogenic liquid storage facility as defined in claim 10, including a water impervious membrane covering the bottom of said excavation between the soil and the adjacent secondary insulation thereon.

13. A cryogenic liquid storage facility as defined in claim 3, wherein said secondary insulation material is sawdust and said primary insulttion material is perlite.

14. A cryogenic liquid storage facility as defined in claim 10, wherein said secondary insulation material is sawdust and said primary insulation material is perlite.

15. A cryogenic liquid storage facility as defined in claim 8, wherein said vapor impermeable barrier layer is an asphalt layer.

16. A cryogenic liquid storage facility as defined in claim 10, wherein said vapor impermeable barrier layer is an asphalt layer.

17. A cryogenic liquid storage facility which comprises an excavation, a container for a cryogenic fluid, means supporting said container in said excavation spaced from the adjacent walls and surfaces of said excavation, a first insulation material in the space between said container and the adjacent walls of said excavation, a retainer wall positioned in said excavation about said container, said retainer wall being spaced from the adjacent wall of said container and from the adjacent walls of said excavation, said first insulation material filling the space between said retainer wall and the adjacent walls of said excavation, said first insulation material also disposed on the bottom of said excavation and below said container, a cover over said container, a cover over the annular space between said container and said retainer wall, a second insulation material positioned over said covers, and a roof positioned over said covers and over said second insulation material thereon.

18. A cryogenic liquid storage facility which comprises an excavation, a container for a cryogenic fluid, means supporting said container in said excavation spaced from the adjacent walls and surfaces of said excavation, a first insulation material in the space between said container and the adjacent walls of said excavation, a retainer wall positioned in said excavation about said container, said retainer wall being spaced from the adjacent wall of said container and from the adjacent walls of said

excavation, said first insulation material filling the space between said retainer wall and the adjacent walls of said excavation, said first insulation material also disposed on the bottom of said excavation and below said container, a second insulation material positioned over said container and over the annular space between said container and said retainer wall, said first insulation material being a secondary insulation material and said second insulation material being a primary insulation material, and including a primary insulation material disposed between said retainer wall and the adjacent wall of said container and also between said secondary insulation material in the bottom of said excavation, and the bottom of said container, a primary insulation material placed over said secondary insulation material in the peripheral area of said excavation just beyond said retainer wall, a vapor impermeable barrier layer positioned over said insulation material in the peripheral area of said excavation beyond said retainer wall, and covering said area at least to the outer periphery of said excavation.

19. A cryogenic liquid storage facility as defined in claim **18**, said barrier layer being in the form of a berm sloping downwardly toward the outer periphery of said excavation, and extending partially over the soil adjacent the outer periphery of said excavation.

20. A cryogenic liquid storage facility which comprises an excavation having sloping walls, a container for a cryogenic fluid, said container having a bottom and

a side wall, means supporting essentially only the bottom of said container in said excavation, with the side wall and the bottom of said container spaced from the adjacent walls and surfaces of said excavation, a first non-rigid insulation material in the space between said container and the adjacent walls of said excavation, said first insulation material being disposed adjacent said sloping walls of said excavation, and a second insulation material positioned over said container and over at least a portion of said excavation.

21. A cryogenic liquid storage facility as defined in claim **20**, wherein said first insulation material is sawdust.

22. A cryogenic liquid storage facility as defined in claim **20**, wherein said first insulation material is sawdust and said second insulation material is perlite.

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