June 11, 1963 | J. J. CLOSNER ETAL | 3,092,933

STORAGE STRUCTURE

Filed July 7, 1961 | 2 Sheets-Sheet 1

Fig. 1.

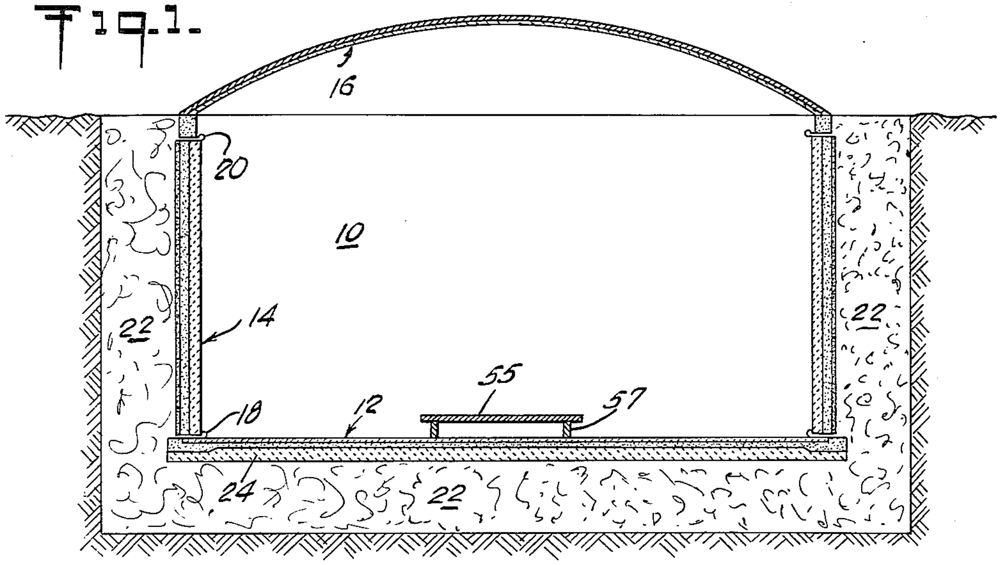

Fig. 2.

Fig. 3.

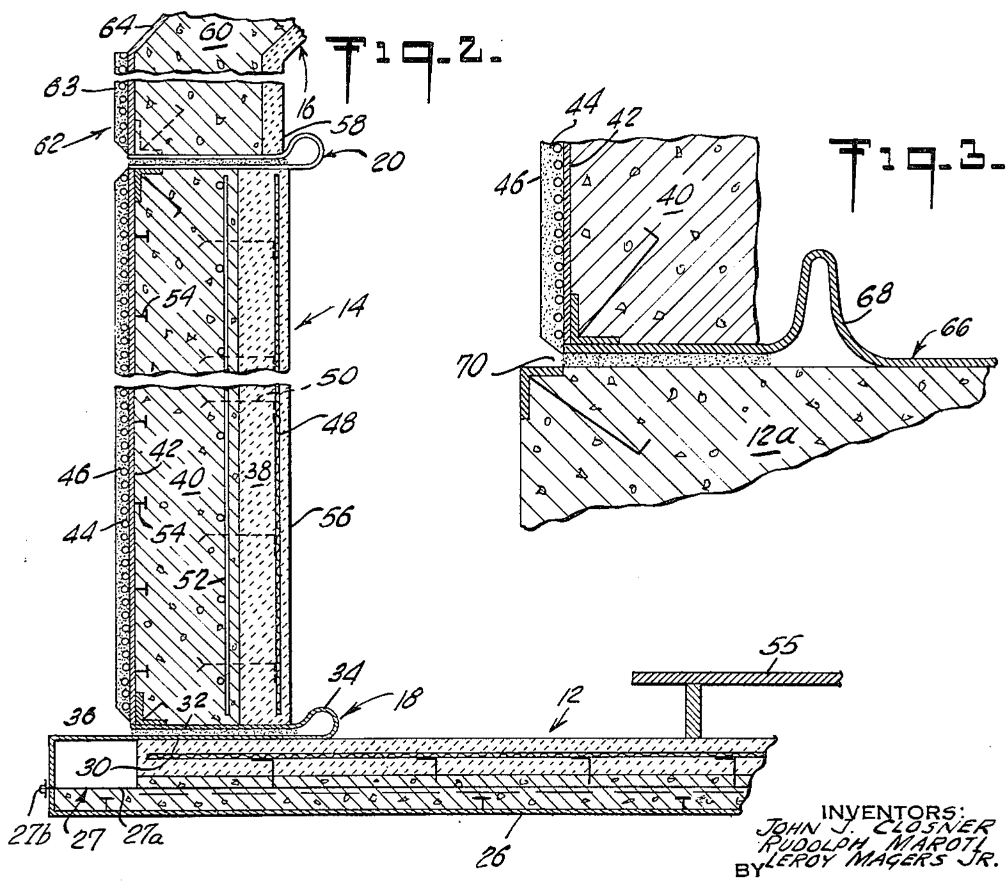

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Fig. 4.

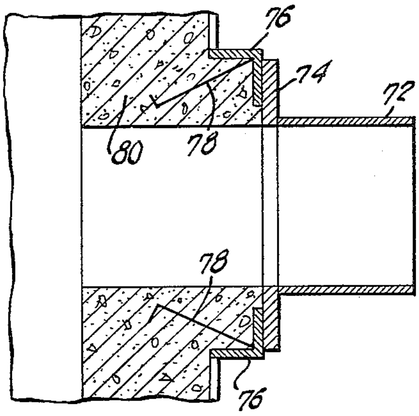


Fig. 5.

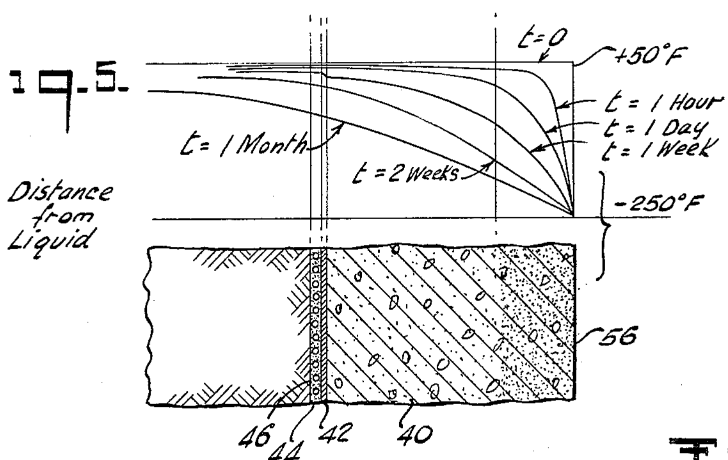


Fig. 6.

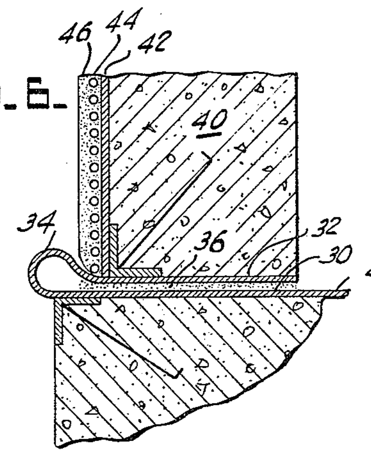
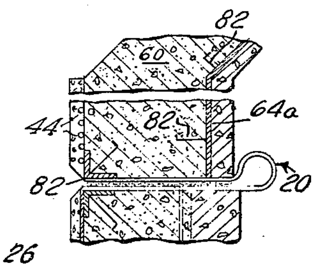


Fig. 7.



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STORAGE STRUCTURE

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20 Claims. (Cl. 50—129)

The present invention relates to structures for storing liquefied gases; the gases being maintained at very low temperatures which are below their boiling points. More particularly, the present invention relates to prestressed reinforced concrete tanks which are liquid and vapor tight and resistant to the thermal change occasioned when the low temperature liquefied gases are introduced into the tank and the interior of the tank begins its cool-down.

Many gases, such as methane, nitrogen, and natural gas, are stored at temperatures far below the usual ambient temperatures so that they may be kept in a liquid condition; thus, permitting very great quantities of the gas to be stored in a limited volume of space. Such low temperature liquefied gases are usually not maintained at high pressure, but rather at about atmospheric pressure or under a pressure of one or two p.s.i. Thus, the storage tank or facility need not be designed for great internal pressure.

While the storage of all liquefied gases has presented problems, the problem of storing natural gas has been a particularly perplexing one. In many areas of the country there is an unusual demand for natural gas during the cold winter months when heating requirements are very high. During these periods of heavy demand, it has heretofore been necessary that large capacity pipe lines be provided to meet the peak loads, even though these lines are only partially used at other times.

In order to reduce the size of the transmission facilities and stock pile natural gas for these peak demand periods, it has been suggested, for example, that natural gas be stored in a gaseous state in large underground caverns and other massive storage areas. The number of natural underground storage facilities are limited by nature and they are not always advantageously located. Such storage facilities, in addition to being scarce, have many natural shortcomings such as seepage which is not readily corrected.

It has also been suggested that lightly constructed tanks be utilized to stock pile gas in the gaseous state against these peak demands.

To overcome the shortcomings of the various forms of prior art storage, the present invention provides prestressed concrete structures in which the gas is stored in its liquefied form and not in the volume consuming gaseous state.

The technique of liquefaction of gases whereby normally gaseous substances are transformed from the gaseous to the liquid state is well known and need not be discussed herein.

The storage of liquefied gases presents many problems and requires that many factors be taken into consideration in constructing a storage facility. One of the factors to be considered is rate of thermal change of the various components of the tank. Thermal shock due to a severe and rapid rate of thermal change may occur when liquefied gas, which must be maintained at a very low temperature at ordinary pressures, is introduced into an empty storage tank. As soon as any appreciable quantity of liquefied gas is placed in an ordinary storage tank of reinforced concrete or steel construction, the inner surfaces of the tank are immediately subjected to thermal change. This thermal change affects the inner surfaces

of the tank so that they are severely and suddenly contracted. This severe and rapid contraction of the inner surfaces sets up great tensile stresses in relation to the remainder of the tank structure which is not immediately affected by the initial impact of the introduced liquefied gas.

Due to the initial thermal change to which the tank is exposed, it is preferred that adequate precautions be taken to insure that a construction is utilized in building the tank which is resistant to thermal change and, yet, which is liquid and vapor tight. The liquid and vapor tight construction is desired due to the hazards inherent in the storage of any normally gaseous substance, particularly an inflammable one such as methane.

Even if the rate of thermal change is reduced by gradually cooling down the tank, there is still the problem of different rates or degrees of contraction of the various components, such as the wall, floor and roof, as well as parts of these. In order to have a uniform cool down throughout the entire tank, the rate of cool down would of necessity have to be so slow that it would tie up the storage tank and the liquefaction apparatus for a prolonged transition period before the full capacity of the tank could be realized.

Ordinary reinforced concrete tanks are not particularly suitable for the storage of liquefied gas since any appreciable rate of thermal change during filling operations may so severely damage the concrete that cracks occur throughout the structure and destroy its liquid and vapor tight characteristics. In some cases the tank may even buckle and collapse under the stress of the sudden contraction.

The combination of a reinforced concrete tank with an interior metal liner to protect against cracking is also unsatisfactory. The interior metal liner is more rapidly affected by thermal change than the concrete wall to which it must be anchored. While concrete and steel (the usual metal used as lining material) have similar coefficients of expansion they have very different coefficients of thermal conductivity. Steel conducts cold or heat quite rapidly, but concrete has a relatively slow rate of conductivity. Accordingly, if an interior steel liner is used with a reinforced concrete tank and even if a gradual cool down is employed, the liner will still contract more quickly than the concrete and tend to pull away from it unless proper reinforcement or contraction precautions are taken.

Even if extreme reinforcing arrangements are utilized with the inner liner, it is necessary that this liner have a minimum thickness to withstand the liquid load substantially as in a free standing steel tank. This is necessary since during the contraction period the liner will for all practical purposes be a freestanding tank. In sharp contrast, the thickness of a metal barrier sheet placed between the prestressing tendons and a concrete core wall of a tank need only be in the order of about 16 to 20 gauge.

By utilizing a prestressed concrete tank construction with a barrier interposed between the concrete core wall and the prestressing tendons, the barrier is placed in compression after prestressing and so maintained. Because the barrier is spaced from the liquefied gas by means of the concrete core wall the barrier cannot contract at a faster rate than the wall since the cold liquefied gas must first cause the core wall to cool down before the barrier is effected. Thus, the inherent faster rate of contraction of a metal sheet barrier is eliminated as a construction consideration since its rate of cooling is controlled by the cooling of the precedingly affected core wall.

Accordingly, it is an object of the present invention to provide a structure for storing liquefied gases which is economical to construct, yet is liquid and vapor tight.

It is another object of the present invention to provide a tank construction which may withstand a rapid rate of thermal change.

It is a further object of the present invention to provide a tank construction which permits the various components of the tank to contract or expand at different rates.

It is still another object of the present invention to provide a structure for storing liquefied gas which permits low cost materials to be utilized in the construction.

In this specification and the accompanying drawings embodiments of the present invention in the storage of liquefied gases are shown. These embodiments are not to be constructed as limiting the invention but, rather they are for the purpose of informing those skilled in the art so that they may practice the invention in many embodiments and within the spirit and scope of the claims which are set forth hereinafter.

In the drawings:

FIGURE 1 is a vertical cross-sectional view of a tank in accordance with the present invention;

FIGURE 2 is a partially fragmentary view of a wall and floor section of the structure of FIGURE 1;

FIGURE 3 is an enlarged detail of an alternate floor liner construction for use in accordance with the present invention;

FIGURE 4 is a sectional detail showing the anchorage of a pipe connection to the tank structure of FIGURE 1;

FIGURE 5 is a graphic presentation of the thermal effect on the concrete wall of a structure which is in accordance with the present invention;

FIGURE 6 is a modified form of a slip joint construction suitable for use with the present invention; and

FIGURE 7 is an enlarged fragmentary sectional detail of an alternate roof construction.

Referring to the drawings and to FIGURES 1 and 2 in particular, a prestressed reinforced concrete tank **10** for storing liquefied gases is shown. The tank **10** is generally comprised of three major components: a floor **12**, a substantially cylindrical wall **14** and a roof structure **16**. Each of the three major components, the floor **12**, the wall **14** and the roof structure **16**, is advantageously permitted to act independently in order to relieve any extreme bending moments which may be encountered when the tank is filled with a liquefied gas or during liquefaction when each major component contracts at a different rate. Accordingly, a sliding joint **18** is provided between the floor **12** and the wall **14** and a sliding joint **20** is provided between the wall **14** and the roof structure **16**.

When liquefied gases, such as those which have boiling points lower than —50° F. and which must be maintained at extremely low temperatures to remain liquefied, are first introduced into the tank **10**, an initial rapid rate of thermal change takes place. The initial quantities of gas placed in the tank immediately vaporizes in the ambient temperature within the tank. This vapor must be pulled out and re-liquefied by liquefaction. This is repeated until such time as the temperature of the interior surfaces of the tank are below the boiling point of the liquefied gas. In effect during this cool down period the interior of the tank is being refrigerated. It is in this cool down period that the sudden flash cooling of the interior of the tank takes place resulting in tensile stresses being set up in the initially contacted surfaces.

During this phase the rate of introduction of liquefied gas and the rate of reliquefaction control the rapidity of cool down. Practical considerations require this period to be as short as possible so that the capacity of the tank may be fully utilized.

Since the floor is the first major portion of the tank to be contacted by the liquid, it will be the first element to be rapidly cooled and it will immediately begin to contract, while the remainder of the tank remains unaffected.

Until the wall **14** becomes affected by the low temperature liquid it will remain substantially in place while the floor **12** contracts. If the floor **12** and wall **14** were integrally joined together, a large bending moment would be developed in the wall **14**. Accordingly, the use of the sliding or slip joint **18** permits relatively free movement of the floor and wall relative to each other without developing any undue moments.

As stated previously, in order to reduce the effect of the rapid thermal change which takes place when the tank is first filled, a gradual cool down of the tank over a period of time may be utilized. This slow cooling using liquefaction apparatus which is well known permits gradual contraction of the various components until a state of equilibrium at the desired low temperature is obtained. However, even with a gradual cool down, the various major components contract at different rates and present problems similar to those encountered with the thermal effect of introducing large quantities of low temperature liquefied gases into the tank. Accordingly, the problems of thermal change still exist even with the use of gradual cool down techniques.

The tank **10** may be constructed above ground or if desired it may be buried as shown in FIGURE 1. By burying the tank, either completely or partially, it is possible to take advantage of the natural insulation qualities of the earth insulated by piling up an earth berm against the tank wall.

In constructing the tank **10** shown in FIGURE 1, an over-sized area is first excavated. Into this excavation a layer of selected granular material **22** should preferably not be of the heaving type when frozen. Next a layer of suitable material **24**, such as asphalt saturated cellular material, is laid down on the granular material **22** to prevent ice from forming outside the tank and bonding to the wall and floor surfaces. The soil will tend to pull away from the tank and if bonded to it, a pulling stress would be developed. The floor **12** which is made of reinforced concrete is next poured in place. Prior to placing the floor **12** an impervious floor barrier **26**, advantageously made of steel may be positioned between the cellular material **24** and the floor **12**. If desired, this floor barrier **26** may be placed on top of the floor **12** as shown in FIGURE 3 and as will be discussed in detail hereinafter.

The floor barrier **26**, if it is placed beneath the concrete floor **12**, is advantageously anchored thereto. When so anchored, the floor **12** and the barrier **26** may be prestressed as a unit so that they are placed under compression prior to the introduction of liquefied gas into the tank.

To prestress the floor **12** and the anchored barrier **26**, a series of tensioning elements **27** are inserted through the floor **12** and tensioned so that both the floor **12** and the barrier **26** are placed in compression at ambient temperatures. Of course, other methods may also be utilized.

The tensioning elements **27** in the illustrated embodiment are comprised of a series of rods *27a* which are horizontally placed in the floor **12** and tensioned so that the floor **12** is prestressed. Attached to the end of each rod *27a* may be any suitable restraining means such as a flat—heat anchor *27b* for maintaining the developed tension.

When the floor **12** and the floor barrier **26** are cooled down by the liquefied gases the previously developed compressive forces must first be relieved before the contraction forces due to the cool down effect the floor and barrier.

Since the floor barrier **26** is in compression at the time of initial cool down, low cost carbon steel may be used rather than the high cost brittle resistant steels, such as stainless. Carbon steels in compression are not adversely affected by low temperatures and brittle fracture is only of importance when the steel is under tension at low temperatures.

A slip or sliding joint 18 is provided by folding over a metallic sheet which, in the illustrated embodiment, is a continuation of the floor barrier 26. The sheet has a lower flap 30, an upper flap 32 and an intermediate bulb portion 34. Between the overlying flaps 30 and 32, a layer of suitable lubricant material 36 is provided. This lubricant material 36 may be graphite, powdered Teflon or similar material which is not adversely affected by extremely low temperatures.

With the floor construction completed, the wall structure 14 may now be commenced. In the embodiment shown in FIGURE 2 in particular, the wall 14 is comprised of an inner layer 38 of thermal insulating material, an intermediate layer 40 of reinforced concrete, a steel barrier sheet 42 which is anchored to the intermediate layer 40, a series of convolutions of prestressing tendons 44 and a cover of protective coating 46 for the prestressing tendons. The inner thermal insulation layer 38 is first placed by forming and pouring. The thermal insulation layer 38 is reinforced by wire mesh 48 and anchored to the reinforced concrete layer by a series of anchors 50. This reinforcement and anchoring of the thermal insulation layer 38 strengthens it against the thermal shock of the flash cooling when liquid gas is first introduced.

This thermal insulation layer 38 may be eliminated if adequate precautions are taken to gradually cool down the tank by having liquefaction of the gas to be stored extended over a period of time sufficient to reduce the danger of thermal shock to the reinforced concrete wall. After the inner surface of the wall is cooled the rate of liquefaction may be increased since the initial shock period is over.

The reinforced concrete layer 40 is reinforced both vertically and horizontally by reinforcement 52. The impervious metal barrier 42 is anchored to the concrete wall by means of a series of anchor studs 54. The position of the impervious barrier 42 may be varied slightly and, if desired, it may be placed within the reinforced concrete portion of the wall. However, it is preferable that the barrier be spaced from the inner surface 56 of the composite wall 14 a distance at least two-thirds the over-all thickness of the composite wall 14. This spacing advantageously permits a substantial portion of the concrete portion of the wall to be cooled first before the barrier is thermally affected. If the insulation layer is eliminated as shown in FIGURE 3, the two-thirds distance is determined from the inner surface of the concrete wall layer 40.

As shown in FIGURE 2 the prestressing tendons 44 are placed about the barrier 42 as well as the layers 38 and 40. As a result of this positioning of the prestressing tendons 44, the barrier 42, intermediate layer of reinforced concrete 40 and the inner layer of thermal insulation 38 are all prestressed as a unit. If the insulation layer 38 is eliminated as discussed previously, then, of course, just the barrier 42 and the concrete layer 40 are prestressed.

Although steel and concrete have substantially the same coefficients of expansion and will contract the same amount at a given temperature they do not have the same coefficients of thermal conductivity. It is this difference in thermal conductivity or rate of contraction which must be carefully considered. As shown in FIGURE 5, the cool down of the concrete wall layer 40 without the inner insulation layer 38 is gradual and uniform even though there may be a flash cooling of the inner surface of the concrete by introducing liquefied gas rapidly tivity through the concrete layer 40, the remotely posi- into the tank. Due to the slow rate of thermal conduc- tioned impervious barrier 42 is not subject to any thermal change which the concrete wall has not already experienced.

As the tank is cooled down to a state of thermal equilibrium, the contraction of the various portions of the wall 14 is gradual and the compressive forces created by the prestressing are relieved. This relief of the prestressing forces must first be accomplished before any tensile stresses due to contraction can be created.

When the tank is fully cooled down and the liquefied gas and the tank are in a state of thermal equilibrium, the various problems of stress and shock are somewhat alleviated. However, in the transition period from an empty ambient temperature tank to the state of equilibrium of a cooled and full tank, the tank must be able to withstand the various transitory stresses which are developed. It is during this transition period that precaution must be taken to protect the structure. Accordingly, by having the wall barrier 42 in a prestressed state of compression prior to the development of the transitory stresses of the cool down period, as well as spaced away from the inside of the tank, the problems of reinforcement occasioned with an inside wall barrier are eliminated.

Since the barrier 42 is in compression, it is possible to use carbon steel rather than stainless steel, thus accomplishing a saving in the cost of material.

During the initial filling operations the inflow of liquefied gas may cause some thermal shock. Accordingly, as a safety measure, a protective shield 55 may be provided above the floor 12 as shown in FIGURES 1 and 2. This shield acts as a protective device to receive the impact of the first liquefied gas dumped into the tank. The shield 55 is preferably of a brittle resistant material such as stainless steel and is positioned above the floor 12. The shield 55 is supported on stud posts 57 or other suitable supports. The posts 57 are advantageously free sliding relative to the floor 12 so that no stress is set up due to the rapid contraction of the shield 55 during the initial filling of the tank 10.

When the liquefied gas strikes the shield 55, it remains in liquefied form for a very short time. Due to the ambient temperatures and normal or slightly elevated pressures in the tank, the liquefied gas quickly gasifies. As the liquid gas continues to evaporate, it gradually reduces the temperature in the tank and particularly the temperature of the inner surfaces of it.

When the inner surfaces are sufficiently cooled the gas will begin to condense within the tank. The actual cool down of the tank as a whole will continue beyond this point since the insulation effect of the concrete 40 prevents a rapid rate of thermal change. However, due to the remote position of the barrier 42, it will not be effected by the continued cool down.

The joint 20 between the wall 14 and the roof structure 16 is constructed similar to the floor joint 18. The roof 16 is the last major unit to be effected by the cool down. Therefore, an insulation layer 58 may be utilized if desired, but it need not necessarily be as thick as the wall insulation layer 38. The roof dome 60 as shown in FIGURES 1 and 2 and to which the layer 58 is applied is also made of reinforced concrete. The dome is prestressed by means of the dome ring 62 which is prestressed by the layer of tendons 63 in a manner similar to tendons 44 and the concrete layer 40.

A roof 64 is provided and it may be a continuation of the joint 20.

The actual roof construction need not of necessity be limited to a concrete structure although such construction is quite economical. A floating type of insulating roof with adequate seals such as a bellows construction may also be used. Of if desired, a post or column supported roof may be used.

As shown in FIGURE 3, a floor liner 66 is provided in an alternate construction. This liner 66 has an expansion bulb 68 at its edge and, if desired, it may be left free sliding on the floor 12*a*. In place of the overlying flaps of joint 18, a slip joint 70 of compacted graphite or similar material may be used.

The expansion bulb 68 of the liner 66 advantageously acts as a short wall to form a pan on the upper surface of the liner **66**. When liquefied gas is introduced into the tank, it is confined within the periphery of the bulb **68**. As stated above, this liquefied gas rapidly gasifies and does not immediately fill the pan. Thus, the unlined concrete wall is protected from sudden thermal change.

The floor **12***a* may advantageously be made of a lightweight expanded concrete and under load it may crack. If it does crack, the tank will not leak since the floor liner **66** acts as a pan. In this construction the floor liner **66** is preferably made of a material which is resistant to low temperature brittle fracture such as stainless steel since it is not under compression as in the first embodiment.

In FIGURE 6 an alternate construction is shown wherein bulb **34** is positioned outside the wall **14**.

In order to insure that piping and other conduits into tank do not break the vapor tightness of the tank during flash cooling, a reinforcement detail is shown in FIGURE 4. A pipe **72** is fixed to a mounting flange **74** and welded to reinforcing angles **76**. The angles **76** are in turn reinforced by anchors **78** which are embedded in concrete **80**. Reinforcements of various types will occur to those skilled in the art and the illustrated embodiment is only for the purpose of illustration.

As shown in FIGURE 7, the roof barrier may be placed on the inside of the roof and fastened by suitable means. In FIGURE 7, the roof barrier **64***a* which is made of steel is fastened to the roof slot **60** by suitable anchors **82**. Since the barrier **64***a* is on the interior of the tank, it would normally be necessary to have a brittle resistant metal. However, since the roof structure is pre-stressed the barrier **64***a* may be of carbon steel.

In this specification and in the claims the use of the term impervious liner is meant to denote one which may be made of plastic, metal or other impervious material which can withstand low temperatures and remain vapor and liquid tight.

We claim:

1. A structure for storing liquefied gases maintained at low temperatures, said structure comprising a floor, a roof, a substantially cylindrical cementitious wall prestressed by a plurality of prestressing tendons and an impervious liquid tight and vapor tight barrier substantially coextensive with said wall interposed between the wall and the prestressing tendons whereby the barrier is prestressed with the wall and is substantially in an initial state of compression at ambient temperatures.

2. A structure for storing liquefied gases maintained at low temperatures as defined in claim 1, wherein the barrier is metal and spaced from the inner surface of the wall a distance about at least two-thirds the thickness of the wall.

3. A structure for storing liquefied gases maintained at low temperatures as defined in claim 1, wherein an impervious liquid tight and vapor tight barrier is placed beneath the floor and is connected to the wall barrier.

4. A structure for storing liquefied gases maintained at low temperatures as defined in claim 1, wherein an impervious liquid tight and vapor tight liner having contraction and expansion means therein is placed on top of the floor and connected to said wall.

5. A structure for storing liquefied gases maintained at low temperatures as defined in claim 1, wherein an impervious liquid tight and vapor tight barrier is placed on top of the roof and connected to the wall barrier.

6. A structure for storing liquefied gases maintained at low temperatures as defined in claim 1, wherein an impervious liquid tight and vapor tight liner substantially coextensive with the roof is anchored to the interior of said roof.

7. A large structure for storing liquefied gases maintained at low temperatures, said structure comprising a floor, a substantially cylindrical reinforced concrete wall prestressed by a plurality of convolutions of high tensile strength prestressing tendons, a continuous and flexible seal between the wall and the floor, and a roof structure; a protective coating covering the prestressing tendons, and

a continuous impervious liquid tight and vapor tight barrier positioned within the convolutions of prestressing tendons and spaced from the inner surface of the wall a distance at least two-thirds the thickness of the wall, said barrier and the wall being in a state of circumferential compression at ambient temperature when the tank is empty.

8. A large structure for storing liquefied gases as defined in claim 7 wherein the wall barrier is metal and positioned between the intermediate layer of concrete and the prestressing tendons.

9. A large structure for storing liquefied gases as defined in claim 7 wherein the continuous, flexible seal comprises a folded sheet of material attached at one side edge to the wall barrier and at the other side edge to a metal liquid tight and vapor tight floor liner.

10. A large structure for storing liquefied gases as defined in claim 7 and further including a flexible waterstop between the wall barrier and the roof structure.

11. A large structure for storing liquefied gases as defined in claim 7 and further including a layer of thermal insulating material placed on the inner surface of the wall and prestressed with the wall barrier and the wall.

12. A large storage tank for storing liquefied gases which are maintained at low temperatures, said tank comprising a floor, a substantially cylindrical wall of cementitious material with a plurality of high tensile strength prestressing tendons tensioned about said wall, a roof structure, a first continuous and flexible waterstop between the floor and the wall, a second flexible waterstop between the roof structure and the wall; a continuous vapor and liquid tight wall barrier positioned within said prestressing tendons, said barrier and the wall being subjected to compressive stresses when the tank is empty and at ambient temperatures, said barrier and waterstops cooperatively connected together.

13. A large storage tank for storing liquified gases as defined in claim 12 and further including a vapor and liquid tight liner on the floor of the tank and connected to the wall.

14. A large storage tank for storing liquified gases as defined in claim 12 and further including a vapor and liquid tight barrier below the floor of the tank and anchored to said floor, said floor and floor barrier being prestressed and subjected to compressive stresses when the tank is empty and at ambient temperatures.

15. A large storage tank for storing liquified gases as defined in claim 12 and further including a layer of thermal insulating material on the inner surface of the roof structure, the tank walls and the floor.

16. A large storage tank for storing liquified gases as defined in claim 12 and further including a vapor and liquid tight barrier on the outer surface of the roof and connected to the second waterstop.

17. A large storage tank for storing liquified gases which are maintained at low temperatures, said tank comprising a floor, a substantially cylindrical reinforced concrete wall, a roof structure, a continuous flexible waterstop between the floor and the wall, a second continuous flexible waterstop between the roof structure and the wall; a continuous metal liquid and vapor tight barrier about the outer surface of the tank, a plurality of high tensile strength prestressing tendons tensioned about the metal barrier and the wall whereby the barrier and the wall are subjected to compressive stresses when the tank is empty and at ambient temperatures, and a protective coating over the prestressing tendons.

18. A large storage tank for storing liquified gases which are maintained at low temperatures, said tank comprising a floor, a substantially cylindrical wall of cementitious material with a plurality of high tensile strength prestressing tendons tensioned about said wall, a roof structure, a first continuous and flexible waterstop between the floor and the wall, a second flexible waterstop between the roof structure and the wall; a continu-

ous vapor and liquid tight wall barrier positioned within said prestressing tendons, said barrier and the wall being subjected to compressive stresses when the tank is empty and at ambient temperatures, said barrier and waterstops cooperatively connected together; the continuous flexible waterstop between the wall and the floor comprising an endless sheet member folded upon itself with one side edge attached to the wall and one side edge attached to the floor, the intermediate portion of the sheet being looped and positioned away from the area of contact between the wall and the floor.

19. A large storage tank for storing liquified gases which are maintained at low temperatures, said tank comprising a floor, a substantially cylindrical wall of cementitious material with a plurality of high tensile strength prestressing tendons tensioned about said wall, a roof structure, a first continuous and flexible waterstop between the floor and the wall, a second flexible waterstop between the roof structure and the wall; a continuous vapor and liquid tight wall barried positioned within said prestressing tendons, said barrier and the wall being subjected to compressive stresses when the tank is empty and at ambient temperatures, said barrier and waterstops cooperatively connected together; the continuous flexible waterstop between the wall and the floor comprising an endless sheet member folded upon itself with one side edge attached to the wall and one side edge attached to the floor, the intermediate portion of the sheet being looped and positioned away from the area of contact between the wall and the floor, and further including anchorage in the wall and the floor to which the side edges of the endless sheet are attached.

20. A large storage tank for storing liquified gases which are maintained at low temperatures, said tank comprising a floor, a substantially cylindrical wall of cementitious material with a plurality of high tensile strength prestressing tendons tensioned about said wall, a roof structure, a first continuous and flexible waterstop between the floor and the wall, a second flexible waterstop between the roof structure and the wall; a continuous vapor and liquid tight wall barrier positioned within said prestressing tendons, said barrier and the wall being subjected to compressive stresses when the tank is empty and at ambient temperatures, said barrier and waterstops cooperatively connected together; the continuous flexible waterstop between the wall and the floor comprising an endless sheet member folded upon itself with one side edge atached to the wall and one side edge attached to the floor, the intermediate portion of the sheet being looped and positioned away from the area of contact between the wall and the floor and further including anchorage in the wall and the floor to which the side edges of the endless sheet are attached, and further including a layer of lubricant between the folded portions of the endless sheet.

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