

March 16, 1948.

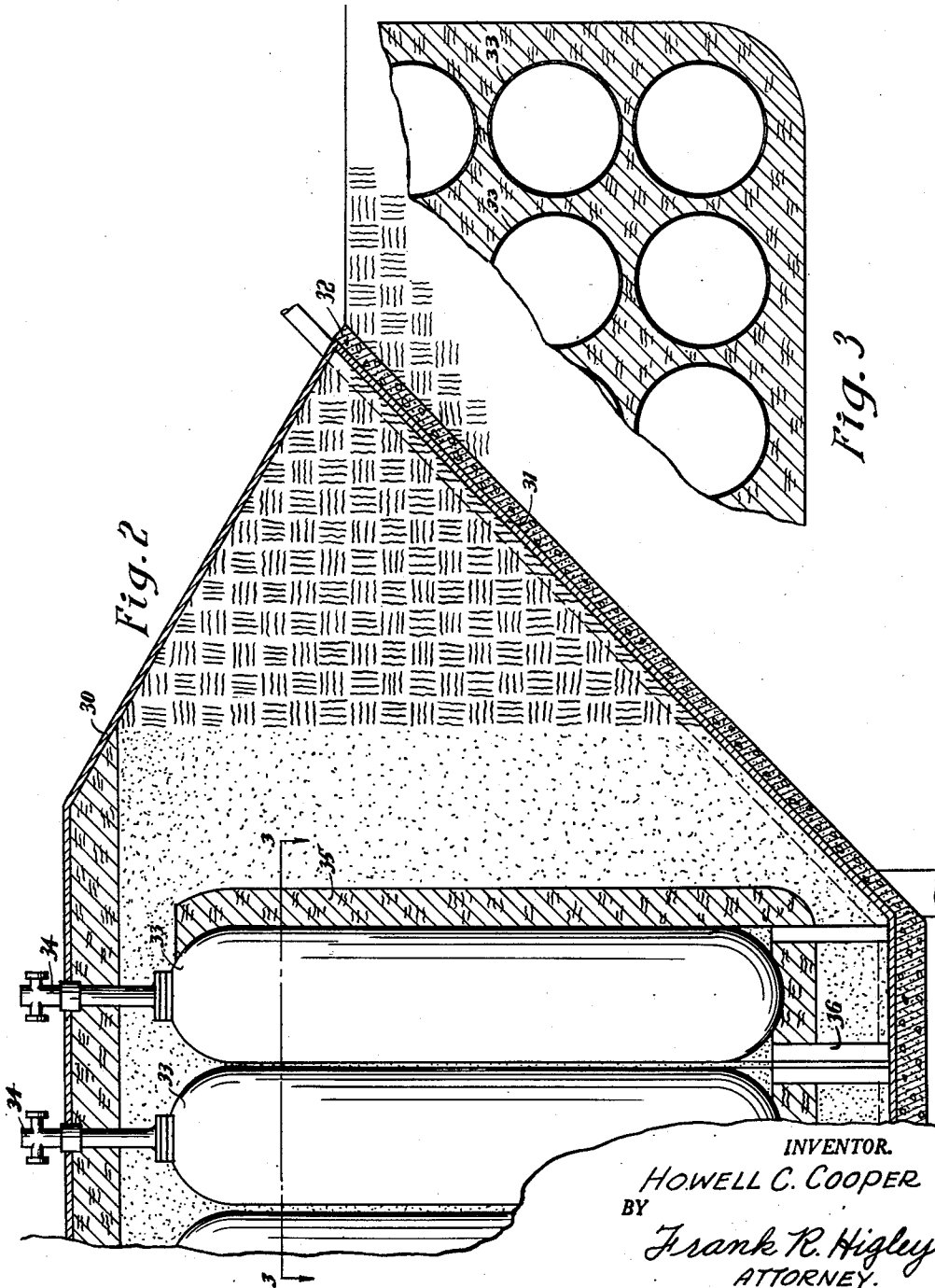
H. C. COOPER

2,437,909

STORAGE MEANS FOR LIQUEFIED GAS

Filed Nov. 27, 1945

3 Sheets-Sheet 2



March 16, 1948.

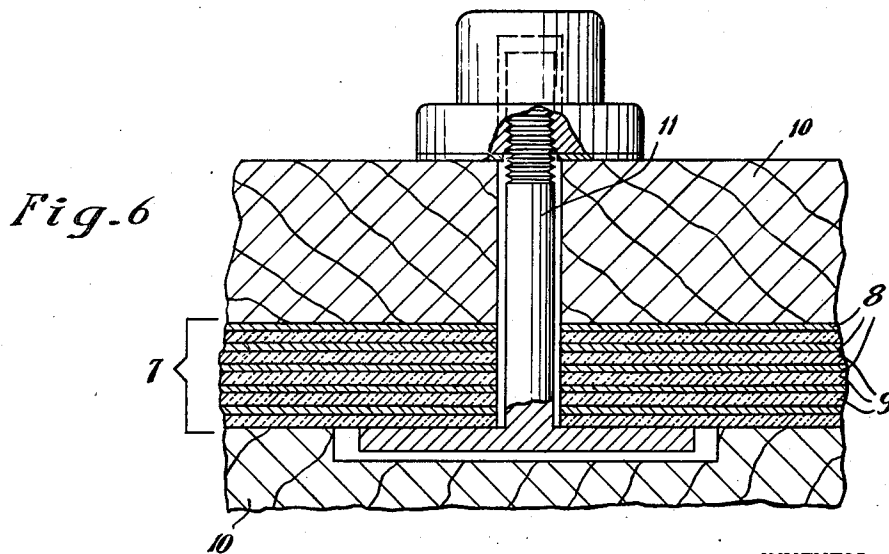
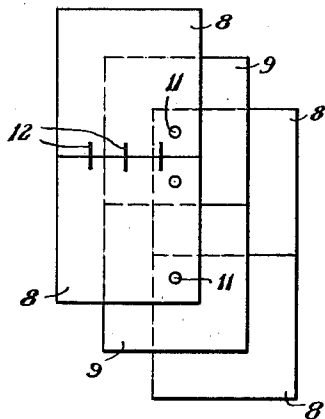
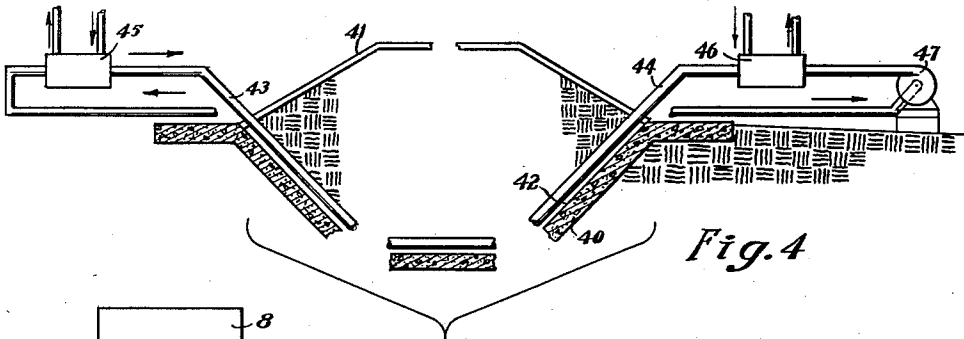
H. C. COOPER

2,437,909

STORAGE MEANS FOR LIQUEFIED GAS

Filed Nov. 27, 1945

3 Sheets-Sheet 3



INVENTOR.

HOWELL C. COOPER

BY

Frank R. Higley
ATTORNEY.

UNITED STATES PATENT OFFICE

2,437,909

STORAGE MEANS FOR LIQUEFIED GAS

Howell C. Cooper, Sewickley, Pa.

Application November 27, 1945, Serial No. 631,021

11 Claims. (Cl. 62—1A)

1

This invention relates to storage means for liquefied gases, such as natural gas or methane, in large quantities in the order of many millions of cubic feet.

Such a substance is a highly inflammable gas at atmospheric pressures and temperatures, and is liquid at atmospheric pressures only at exceedingly low temperatures in the order of -258° F., and further is lighter than air when gaseous and heavier than air when liquid; and experience has shown that its storage in sufficiently large quantities to be practically useful presents a very substantial problem.

The general objects of this invention are to provide safe storage for the liquefied gas in large quantities.

More particularly, the invention contemplates for the purpose location of the liquid in an earth cavity within a vapor-proof sheath vented for relief and recovery of such gasification as is caused by necessary heat losses; together with provision for emergencies such as might be caused by bombing, airplane crashes and the like from without, and leakage of the receptacle proper, from within. An important feature of the invention to these ends is to provide a receptacle for the liquid within the sheath and separated from the walls thereof by detritus forming a matrix defining intercommunicating voids as will appear.

Another object is to provide for maintenance of the liner of the cavity against thermal conditions which would otherwise impair it; and still another object is to provide novel liquid and vapor-proof liner means capable of withstanding the tremendous temperature changes involved.

Further objects and advantages will be apparent from the following description and claims taken in connection with the accompanying drawings wherein

Fig. 1 is a typical sectional elevation of an embodiment of the invention wherein a single large receptacle is employed for the liquid;

Fig. 2 is a fragmentary sectional elevation of an embodiment wherein a plurality of smaller receptacles are provided for the liquid;

Fig. 3 is a fragmentary horizontal section as in the plane of line 3—3, Fig. 2;

Fig. 4 is a diagrammatic view as in vertical section illustrating the heating system employed;

Fig. 5 is a diagrammatic view illustrative of the manner of assembling the vapor-proof liner employed; and

Fig. 6 is a sectional detail of the vapor proof liner.

With reference now to the drawings and first

2

to Fig. 1 thereof, a reservoir cavity is formed by excavation or otherwise in surrounding earth 1, the cavity being preferably either circular or rectangular as dictated by circumstances. Excavated earth may be employed about the periphery of the cavity to give it greater effective depth, if desired, as is usual in reservoir construction; and the side walls of the cavity are upwardly divergent preferably in approximation to the angle of repose. On this basis the mouth of the cavity will be of the order of 150 feet by 150 feet, assuming the cavity to be a square one, for a capacity in the order of forty-two million cubic feet of gas, there being an advantage of around 600 to 1 in volume attained by liquefaction, as will be appreciated by one familiar with the art.

The cavity is lined with a thick wall of concrete 2 with detritus-containing sump means therebelow as at 3, served by an open ended pipe 4 extending thereto and suitable suction pump not shown, to combat exposure of the liner to excessive external accumulated moisture.

Vapor-proof sheath means are provided including a cover portion 5 over the mouth of the cavity and a liner portion 6 overlaid on the concrete wall 2.

The vapor-proof liner 6 is preferably of laminated construction illustrated in detail in Figs. 5 and 6 and consists of a laminate stratum 7 of alternate metallic and non-metallic laminations 8 and 9, respectively, each lamination consisting of a plurality of panels laid edge to edge to form joints disposed in staggered relation to those of the next lamination as indicated in Fig. 5. Materials for the laminations 8 and 9 may be low temperature nickel, steel and asbestos sheet, respectively. The laminate stratum 7 may be enclosed between inner and outer layers 10 of wood or the like and bolt means 11 are arranged to secure the laminate assembly and for the purpose located each to pass through one of the panels in each of the laminations. Preferably also calking is provided, of lead or the like in notches spaced at intervals along adjacent edges of adjacent panels as conventionally indicated at 12, to prevent leakage along the corresponding edges.

By the arrangement described, the completed liner is both vapor and water proof and effectively continuous although its component parts may have relative give in their planes, to accommodate temperature changes, even when extreme and localized.

The cover portion 5 of the sheath may be of any desired and suitable construction such as of

welded metal. It is vented as at 13 for exit of gas past its associated liquid seal 14.

Within the sheath a liquid receptacle is provided having upwardly divergent walls spaced from those of the cavity. As herein indicated, the walls consist of a liquid-proof liner 15 which may be the same construction as described in connection with Figs. 5 and 6 of the drawings, supported in spaced relation from the cavity walls as by wood facing 16 overlaid on runners 17, supported on posts 18, rising from a wood facing 19 overlaid upon the vapor-proof liner 8.

A pipe line 20 is arranged leading to and from the bottom of the receptacle for filling and emptying it respectively.

According to my invention, the space within the sheath both within and about the receptacle is substantially filled with detritus of a nature to form a matrix defining intercommunicating voids. The detritus may be in the form of sand, gravel having the advantage of cheapness, or it might be in larger particles of more elaborate form, such as marbles or rings or cylinders. Preferably the material of the detritus is of substantially specific heat so that the detritus will provide a corresponding thermal mass. If desired also, a layer of cork as at 21 may be incorporated to improve thermal insulation, the layer being located preferably immediately above the liquid level within the receptacle. At any rate, it will be observed that the detritus below the receptacle helps to support it; the detritus above the receptacle serves to support the cover portion 5 of the vapor-proof sheath and each portion of the detritus impedes a siphonic circulation theread-jacent so that thermal losses are minimized.

It is to be noted that ordinarily the voids formed by the detritus about and below the receptacle form emergency volume for receiving liquid should the receptacle leak. Also under such condition, the thermal mass provided by the detritus itself will retard gasification of such leakage and in case of fire substantially inhibit combustion. The detritus within the sheath serves for cover support, and that above the liquid level provides insulation against solar heat and also substantial volume for sudden emergency gasification. The upwardly divergent form of the receptacle and cavity assists in this. Obviously, damage by bomb, airplane crash and the like will be minimized by the construction described, and particularly the detritus which would greatly impede any entrance by any such object.

With reference now to the modification of Fig. 2, the construction is generally the same as before. A vapor-proof casing consisting of cover portion 30 and liner portion 31 is provided, the latter being overlaid on a concrete wall 32 as before. However, instead of a single receptacle within the sheath, a plurality of metallic bottles 33 are arranged therein each having filling and emptying means 34 extending through the cover 30; insulation such as cork 35 is arranged about the bottles and the latter are suitably supported as indicated at 36 above the bottom of the sheath, detritus being employed below, between, above and about the bottles. Such construction has the advantage that leakage of one bottle does not necessarily impair the others, and any may be withdrawn for repair, if necessary.

Obviously, in either of the forms described the aggregate volume of the voids provided by the detritus about and below the liquid receptacle volume is sufficient that upon receptacle failure

the resultant liquid level in the voids will be below a substantial amount of detritus so that there will always be a substantial detritus void above such liquid level, with the advantages described above; and such liquid level will remain below the level of the surrounding earth.

In order to preserve the cavity liners 2 and 32 against cracking, and otherwise maintain them as nearly vapor proof as possible, I provide means for preventing freezing temperature thereof from the refrigerant effect of the receptacle contents. Such means is conventionally illustrated in Fig. 4 wherein 40 represents the concrete cavity liner, and 41 and 42 represent the cover and liner portions of the vapor-proof sheath. Accordingly I provide heating means overlaid on the liner, here shown as in the form of piping as indicated with passes 43 and 44 leading back and forth across the liner, heat exchangers 45 and 46 on opposite sides of the cavity and an impeller 47 for maintaining circulation of a heating medium as indicated by the arrows, a gaseous medium being employed for the purpose to avoid escaping vapors so far as possible.

I claim:

1. In combination with an earth cavity for the purpose described, a receptacle for liquefied natural gas within said cavity, said cavity having a vapor proof sheath including cooperative liner and cover portions and said receptacle having filling and withdrawing means extending through said sheath, and detritus within said sheath about said receptacle forming a matrix defining intercommunicating voids providing an aggregate volume sufficient to accommodate the contents of said receptacle substantially below the level of the surrounding earth.

2. In combination with an earth cavity for the purpose described, a receptacle for liquefied natural gas within said cavity, said cavity having a vapor proof sheath including cooperative liner and cover portions and said receptacle having filling and withdrawing means extending through said sheath, and detritus within said cavity about said receptacle forming a matrix defining intercommunicating voids providing an aggregate volume sufficient that should said receptacle fail, the resultant liquid level in said voids will be below a substantial amount of said detritus.

3. In combination with an earth cavity, for the purpose described a vapor proof liner for said cavity, a receptacle for liquefied natural gas within said liner, detritus about and below said receptacle, and heating means for opposing the refrigerant effect of said gas within said receptacle, to maintain said liner above freezing temperature, said heating means comprising piping overlaid on said liner, and means for circulating a heating medium through said piping.

4. In combination with an earth cavity, for the purpose described a vapor proof liner for said cavity, a receptacle for liquefied natural gas within said liner, detritus about and below said receptacle, and heating means for opposing the refrigerant effect of said gas within said receptacle, to maintain said liner above freezing temperature, said heating means comprising piping overlaid on said liner, means for circulating a heating medium through said piping and means outside said cavity for heating said medium.

5. In combination with an earth cavity, for the purpose described, a vapor proof liner for said cavity, a receptacle for liquefied natural gas within said liner, detritus about and below said receptacle, and heating means for opposing the

5

refrigerant effect of said gas within said receptacle, to maintain said liner above freezing temperature, said heating means comprising piping overlaid on said liner in stretches leading back and forth from one side to the other, means for circulating a heating medium through said piping, and means at the opposite sides of said cavity for heating said medium.

6. In combination with an earth cavity for the purpose described, a vapor proof liner for said cavity, a receptacle for liquefied natural gas within said liner, and detritus within said cavity about said receptacle, said liner including a laminate stratum, said stratum consisting of alternate metallic and non-metallic laminations, each lamination consisting of a plurality of panels laid edge to edge to form joints disposed in staggered relation to those of the next lamination.

7. In combination with an earth cavity for the purpose described, a vapor proof liner for said cavity, a receptacle for liquefied natural gas within said liner, and detritus within said cavity about said receptacle, said liner including a laminate stratum on a continuous concrete bed, said stratum consisting of alternate metallic and non-metallic laminations, each lamination consisting of a plurality of panels laid edge to edge to form joints disposed in staggered relation to those of the next lamination.

8. In combination with an earth cavity for the purpose described, a vapor proof liner for said cavity, a receptacle for liquefied natural gas within said liner, and detritus within said cavity about said receptacle, said liner including a laminate stratum, said stratum consisting of alternate metallic and non-metallic laminations, each lamination consisting of a plurality of panels laid edge to edge to form joints disposed in staggered relation to those of the next lamination, and bolt means arranged to secure the laminate assembly and for the purpose located each to pass through one of said panels in each of said laminations.

6

9. In combination with an earth cavity for the purpose described, a vapor proof liner for said cavity, a receptacle for liquefied natural gas within said liner, and detritus within said cavity about said receptacle, said liner including a laminate stratum, said stratum consisting of alternate metallic and non-metallic laminations, each lamination consisting of a plurality of panels laid edge to edge to form joints disposed in staggered relation to those of the next lamination, said panel edges being notched and packed to prevent leakage therealong.

10. In combination with an earth cavity for the purpose described, a vapor proof liner for said cavity, a receptacle for liquefied natural gas within said liner, and detritus within said cavity about said receptacle, said liner including a laminate stratum, said stratum consisting of alternate metallic and non-metallic laminations, each lamination consisting of a plurality of panels laid edge to edge to form joints disposed in staggered relation to those of the next lamination, said stratum being interposed between a pair of wood layers.

11. In combination with an earth cavity having upwardly divergent sides, a vented vapor proof sheath for said cavity, a receptacle for liquefied natural gas within said sheath and having upwardly divergent sides, and detritus within said sheath, within and about said receptacle and extending thereabove.

HOWELL C. COOPER.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,489,725	Wilson	Apr. 8, 1924
2,166,913	Little	July 18, 1939
2,256,673	Hansen	Sept. 23, 1941
2,333,315	Klingberg	Nov. 2, 1943