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TANK FOR STORING LOW TEMPERATURE LIQUIDS
IN AMBIENT SURROUNDINGS
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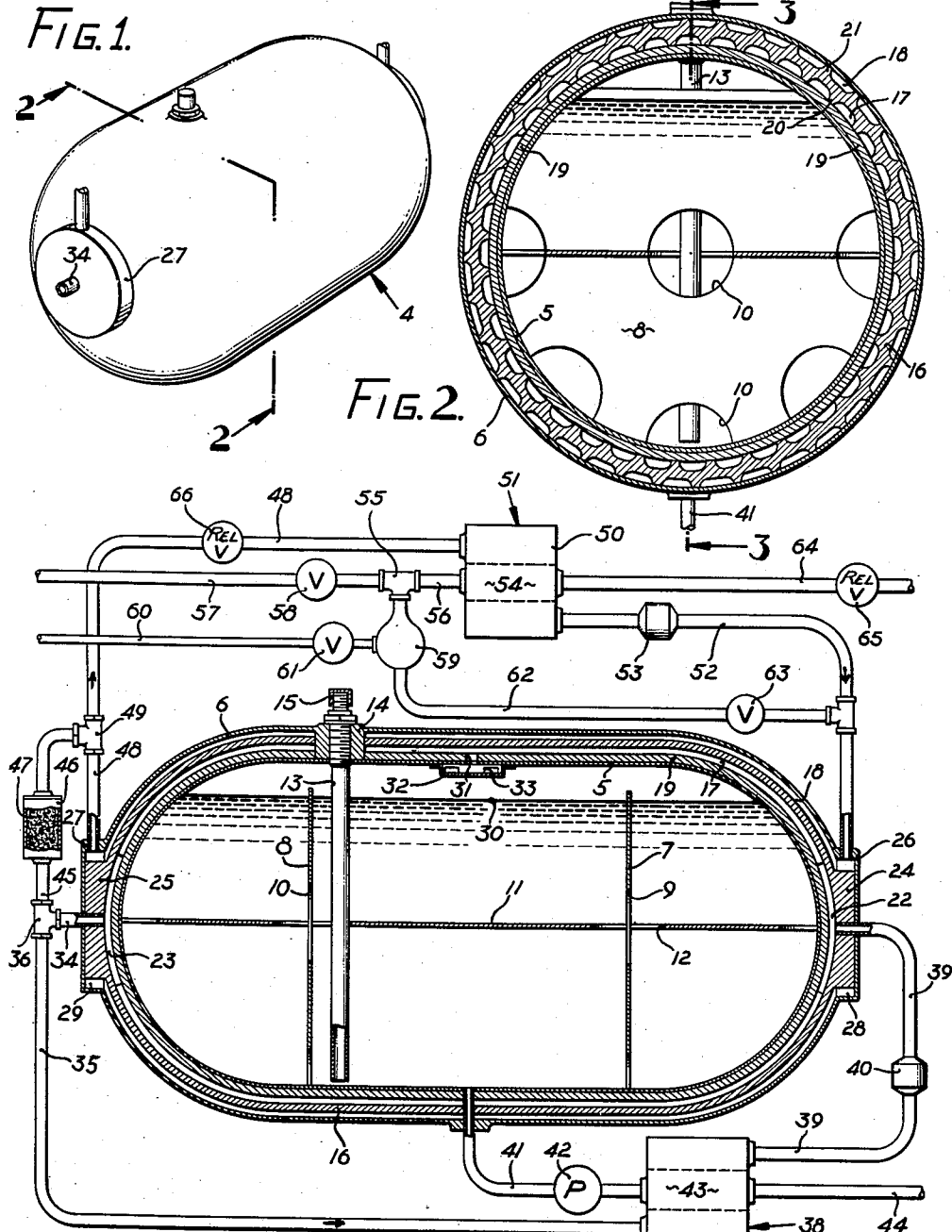


FIG. 3.

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TANK FOR STORING LOW TEMPERATURE LIQUIDS IN AMBIENT SURROUNDINGS

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14 Claims. (Cl. 62—53)

This invention relates to a tank for storing low temperature liquids in ambient surroundings and more particularly to the storage tank which includes both means for cooling the low temperature liquid and means for maintaining the outside surface of said tank at about ambient temperature in order to prevent the formation of excessive frost on the exterior of the tank.

When a low temperature liquid, such as liquid hydrogen, is utilized as fuel for a non-air breathing engine or in other processes, it is necessary to store the low temperature liquid without excessive evaporation. Also, when the liquid is utilized in ambient surroundings, a considerable amount of frost will normally form on the exterior surface of the container because of the low temperature of the liquid. In the liquid storage tank disclosed in pending U.S. application Serial No. 417,658 filed March 22, 1954 by Randolph Samuel Rae, the cold evaporated gases are recirculated around the low temperature liquid container in order to maintain the liquid at about the liquification temperature. Also, as disclosed in pending U.S. application Serial No. 457,173 filed September 20, 1954 by Randolph Samuel Rae, it is possible to utilize a separate refrigerant of lower temperature than the liquid being stored in order to prevent excessive evaporation of the liquid. By the present invention, two separate passage means are provided around the container for the low temperature liquids. The first passage means is for the recirculation of the evaporated gases in order to continually cool the liquid within the tank and these recirculated gases are cooled to a low temperature by passing through a heat exchanger connected to the low temperature liquid supply. In the second passage means, a quantity of the evaporated gas is circulated around the outer shell of the tank and is heated to about ambient temperature in order to maintain the outer skin of the tank at about ambient temperature and thereby eliminate the formation of frost on the exterior of the tank. The gas circulated in this passage means can be heated by the engine exhaust or by burning a portion of this circulate gas in a combustion chamber. Also, provision is made to supply gas to the second passage means from the first passage means when the pressure in the first passage means exceeds a predetermined value. The tank of this invention is particularly suitable for storage of liquid hydrogen which, in gas form, can be combusted to heat the outer skin of the tank.

It is therefore an object of the present invention to provide a storage tank for low temperature liquids which has its outer skin continually maintained at about ambient temperature in order to prevent the formation of frost on the outer skin.

Another object of the invention is to provide a tank for storing low temperature liquids in which the evaporated liquid is recirculated around the inner container to prevent excessive evaporation and a portion of the evaporated liquid is supplied to a heating cycle which

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maintains the outer skin of the tank at about ambient temperature.

Another object of the invention is to provide a liquid storage tank having inner passage means associated with the inner container to maintain the low temperature liquid with minimum evaporation and having an outer passage means containing evaporated gas at about ambient temperature in order to prevent formation of frost on the exterior of the tank.

These and other objects of the invention not specifically set forth above will become readily apparent from the accompanying description and drawings in which,

Figure 1 is a perspective view of the storage tank of the present invention illustrating the shape of the tank.

Figure 2 is a transverse vertical section along line 2—2 of Figure 1 illustrating the inner and outer passages for the tank and the baffles for the tank.

Figure 3 is a vertical section along line 3—3 of Figure 2 illustrating the apparatus associated with the tank for cooling the low temperature liquid and for heating the outside skin of the tank.

Referring to Figure 1, the tank is illustrated as having a cylindrical center section with dome shaped ends. The tank is formed of an inner container 5 which can be constructed of any suitable material, such as steel or plastic, and an outer skin 6 which can likewise be constructed of any suitable material. The inner container supports a pair of vertical baffles 7 and 8 which have openings 9 and 10, respectively, in order to permit some movement of the liquid within the tank. Also, a horizontal baffle 11 is supported by the inner container and has openings 12 for permitting some vertical movement of the liquid within the tank. An inlet passage 13 passes through the outer skin and the inner container and is secured to a fitting 14. The inlet passage discharges near the bottom of the tank and has a cap 15 to seal the passage when not in use. The outer shell and inner container are separated by an insulating member 16 in which is formed a plurality of inner passages 17 and a plurality of outer passages 18. The outer passages 18 are closed by the outer skin 6 of the tank while the inner passages 17 are in contact with an insulating layer 19 of uniform thickness which surrounds the inner container 5. Each of the passages 17 and 18 pass completely around the tank and are separated from one another by projections 20 and 21, respectively, of member 16. The passages 17 all communicate with a header space 22 at one end of the tank and with a header space 23 at the other end of the tank and these header spaces are closed by circular enlargements 24 and 25, respectively, formed at each end of the member 16. The outer skin 6 has circular extensions 26 and 27 at opposite dome ends of the tank and these circular members are larger in diameter than the enlargements 24 and 25, respectively, in order to form header spaces 28 and 29 at the ends of the tank with which the passages 18 connect.

Referring now to the cooling system including passages 17, the gases evaporating from the level 30 of the low temperature liquid are led through passage 31 to the center passage 17. Passage 31 is protected by a plate 32 secured to the underside of the inner container 5 and by baffles 33. These evaporated gases pass to header space 23 where they are intermingled with previously evaporated gases received from all of the passages 17. A passage 34 extends through enlargement member 25 and connects with header space 23 and is also connected to a passage 35 through a fitting 36. Passage 35 connects with the outer chamber 37 of heat exchanger 38 and the discharge from the outer chamber is connected with

header 22 through passage 39 and blower 40. The blower 40 serves to continually recirculate the cooled evaporated gases through the heat exchanger 38 and through the passages 17. The low temperature liquid within the inner container 5 is withdrawn through passage 41 containing a pump 42 and the passage 41 leads to the inner chamber 43 of heat exchanger 38 which in turn is connected by passage 44 to the point of use, such as non-air breathing engine or other process. The low temperature liquid will be evaporated in inner chamber 43 by the heat absorbed from the recirculated gases in chamber 37 and the recirculated gas in passage 39 will be at about the liquefaction temperature of the low temperature liquid. By recirculating the cooled evaporated gases around the inner container of the tank by blower 40, the amount of gas which will evaporate from the liquid will be substantially reduced.

Since the liquid will continue to evaporate to form more gas, it is necessary to permit a portion of the gas from the cooling passages 17 to escape. For this purpose, a passage 45 connects with fitting 36 and has an enlarged portion 46 which contains a packing 47, the enlarged portion being connected with a passage 48 through a fitting 49. The packing 47 acts as a resistant to the flow of evaporated gas through passage 45 to passage 48 and permits flow only when the pressure of the gas in passage 45 exceeds a predetermined value. Therefore, the packing serves as a release valve to prevent the pressure in the cooling passages 17 from exceeding a set value.

The heating system which serves to maintain the outer skin of the tank at about ambient temperature, will now be described. The passage 48 connects with the discharge header 29 and with the outer chamber 50 of heat exchanger 51. The outer chamber 50 is also connected with the inlet header 28 through passage 52 which contains blower 53 to maintain circulation of the gases through passages 18. The inner chamber 54 of heat exchanger 51 is connected to fitting 55 through passage 56 and two alternate passages are connected with fitting 55 in order to supply heating gases through passage 56 to chamber 54. In the event the low temperature liquid, such as hydrogen, is utilized as a fuel for a non-air breathing engine, the exhaust of the engine can be connected to fitting 55 through passage 57 which contains a valve 58 for regulating the amount of exhaust supplied to the chamber 54. Also, a combustion chamber 59 is connected to fitting 55 and is supplied with oxygen gas or other oxidant through passage 60 which contains a valve 61 for regulating the supply. The fuel supplied to the combustion chamber is withdrawn from passage 52 through passage 62 which also contains a valve 63 for regulating the fuel supply to the combustion chamber. When the valve 58 is closed and the valves 61 and 63 are regulated, a portion of the evaporated gas in the heating cycle is continually withdrawn and combusted in combustion chamber 59, and the combustion products are discharged to atmosphere through a passage 64, which contains a release valve 65 in order to prevent the pressure in the combustion chamber from exceeding a predetermined value. By continually combusting a portion of the evaporated gases in the heating system, the pressure in this system including passages 18 will be continually relieved.

When it is desired to heat the gases in the heating system by engine exhaust only, the valves 61 and 63 are closed and the valve 58 is regulated to supply the desired amount of heat to heat exchanger 51, and the exhaust gases are exhausted to atmosphere through passage 64 and the pressure of the exhaust is maintained at the desired value by release valve 65. When both valves 61 and 63 are closed, there will be no evaporated gas withdrawn from the heating system and therefore a release valve 66 is placed in passage 48 in order to prevent the pressure in the heating system from exceeding a pre-

selected value. In operation of the heating system, a portion of the evaporated gas is supplied to this system through passage 45 to passage 48 and the gases are heated in heat exchanger 51 to about ambient temperature. The circulation of these heated gases through passages 18 serve to maintain the outer skin 6 of the tank at about ambient temperature so that frost will not form on the outer skin of the tank. It is understood that the heated gases entering header 28 will be at somewhat higher temperature than the gases leaving header 29 and that the heat exchanger 51 can be regulated to maintain the average temperature of the outer skin at about ambient temperature. The formation of frost, of course, is undesirable since it adds weight to the tank and makes it difficult to utilize the tank in connection with other structure. The oxygen supply passage 60 can connect with any available oxygen supply and the heat exchangers can be of any desired construction. Of course, both engine exhaust and the combustion chamber 59 can be used at the same time by proper regulation of valves 58, 61 and 63.

While the tank has been described as containing a low temperature liquid, it is apparent that this low temperature substance must be in the form of a fuel, such as liquid hydrogen, if combustion chamber 59 is to be utilized. By the present invention, a storage tank for a low temperature liquid has been provided in which the inner container of the tank is continually cooled by cold gases evaporating from the liquid and these gases are further cooled by the low-temperature liquid itself. In addition, the tank is supplied with a heating system which warms the outer skin of the tank to about ambient temperature and prevents the formation of frost on the tank. This heating cycle can utilize either the exhaust from an engine or can continually utilize a portion of the evaporated gases in a combustion chamber. It is understood that the only heat transferred to the low temperature liquid in the inner container will be from these ambient gases in the passages 18 and the insulating members 16 and 19 resist such heat transfer. Various types of passage constructions can be provided between the outer skin and inner container and the shape and size of the tank can be varied in accordance with the use of the tank. Various other modifications are contemplated by those skilled in the art without departing from the spirit and scope of the invention as hereinafter defined by the appended claims.

What is claimed is:

1. An apparatus for storing gas material in the form of a low temperature liquid comprising a tank having an inner container for housing said liquid and an outer skin, a uniform layer of insulation covering said inner container, an insulation member positioned between said uniform layer and said outer skin and having a plurality of inner passages on its inner surface and a plurality of outer passages formed on its outer surface adjacent said outer skin, separate header means formed at each end of said tank for said inner passages and for said outer passages, means for passing the gas evaporating from said liquid to said inner passages, means for circulating said gas from one header means to the other header means for said inner passages and through said inner passages, heat exchanger means for cooling said circulated gas in said inner passages with the low temperature liquid withdrawn from said inner container, means for supplying evaporated gas to said outer passages from said inner passages and containing a pressure relief valve to control the pressure in said inner passages, and means for heating the gas circulated in said outer passages to maintain said outer skin at about ambient temperature.

2. An apparatus as defined in claim 1 having combustion chamber means utilizing a portion of the gas in said outer passages as fuel, and separate means for supplying an oxidant to said combustion chamber means, said com-

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bustion chamber means supplying high temperature heating medium to said heating means.

3. An apparatus as defined in claim 1 wherein said heating means receives a high temperature gas supply as the heating medium, said heating means being exhausted to atmosphere through a conduit containing a release valve for maintaining the desired pressure within said heating means.

4. An apparatus for storing gas material in the form of a low temperature liquid comprising a tank having an inner container and an outer skin, first passage means surrounding said inner container of said tank and connected with the gas evaporating from said liquid, means for recirculating evaporated gas through said first passage means to thereby insulate said liquid, second passage means surrounding the outer skin of said tank and connected with gases evaporating from said tank, heat exchange means connected with said second passage means for raising the temperature of the gas in the said second passage means, and means for recirculating evaporated gas through said second passage means and said heat exchanger means to maintain said outer skin at about ambient temperature.

5. An apparatus as defined in claim 4 having means for removing the low temperature liquid from said tank, a heat exchanger connected with said first passage means and with said removing means for cooling the gas recirculated through said first passage means with the liquid removed from the tank.

6. An apparatus as defined in claim 4 having means connecting said first passage means with said second passage means for supplying evaporated gas to said second passage means.

7. An apparatus for storing gas material in the form of low temperature liquid, comprising a tank, first means for collecting cold gas evaporating from said liquid and recirculating said gas around said low temperature liquid in said tank to insulate said liquid, second means for circulating a heating medium around the outer surface of said tank to heat said surface and prevent the formation of frost thereon, said evaporated gas being combustible, combustion means supplied with said gas and an oxidant for maintaining combustion therein and producing heat, and heat exchanger means connected with said combustion means and with said second means for raising the temperature of said heating medium.

8. An apparatus as defined in claim 7 wherein said liquid and evaporated gas is hydrogen.

9. An apparatus for storing gas material in the form of a low temperature liquid comprising a tank having an inner container for housing said liquid and an outer skin separated from said inner container, first passage means positioned adjacent said inner container, means for connecting said first passage means with gas evaporated from said liquid in order to insulate said liquid, second passage means positioned adjacent said outer skin, means for connecting said second passage means with a heating medium, means for heating said medium in said second passage means to maintain said outer skin at about ambient temperature and prevent the formation of frost, said evaporated gas being combustible, said heating means comprising combustion means supplied with evaporated gas and an oxidant for maintaining combustion therein and producing heat and heat exchanger means

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connected with said combustion means and with said second passage means for raising the temperature of said heating medium.

10. An apparatus for storing gas material in the form of a low temperature liquid comprising a tank having an inner container for housing said liquid and an outer skin separated from said inner container, first passage means positioned adjacent said inner container, means for connecting said first passage means with gas evaporated from said liquid in order to insulate said liquid, second passage means positioned adjacent said outer skin, means for connecting said second passage means with a heating medium, means for heating said medium in said second passage means to maintain said outer skin at about ambient temperature and prevent the formation of frost, said heating medium comprising evaporated gas, and means for supplying said evaporated gas to said second passage means from said first passage means.

11. An apparatus as defined in claim 10 wherein said heating means comprises a heat exchanger connected with said second passage means, and combustion means for combusting gas received from said second passage means to supply heat for said heat exchanger.

12. An apparatus as defined in claim 10 wherein said supply means comprises a conduit means containing a relief valve for controlling the pressure in said first passage means and the flow of gas from said first passage means to said second passage means.

13. An apparatus for storing gas in the form of a low temperature liquid comprising an inner container for housing said liquid, an outer skin separated from said inner container, substantially the entire space between said container and skin containing only first and second passage means separated by insulation means, said insulation means enclosing said inner container, said first passage means being located at one side of and inwardly of said insulation means and positioned adjacent said inner container, means for connecting said first passage means with gas evaporated from said liquid in order to insulate said liquid, said second passage means being located at the other side of and outwardly of said insulation means and adjacent said outer skin, means for connecting said second passage means with a heating medium, and means for heating said medium in said second passage means to maintain said outer skin at about ambient temperature to prevent the formation of frost.

14. An apparatus as defined in claim 13 having heat exchange means connected with said first passage means and with said low temperature liquid in said inner container, and means for recirculating the evaporated gas in said first passage means through said heat exchange means to cool the gas in said first passage means with the liquid withdrawn from the inner container.

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