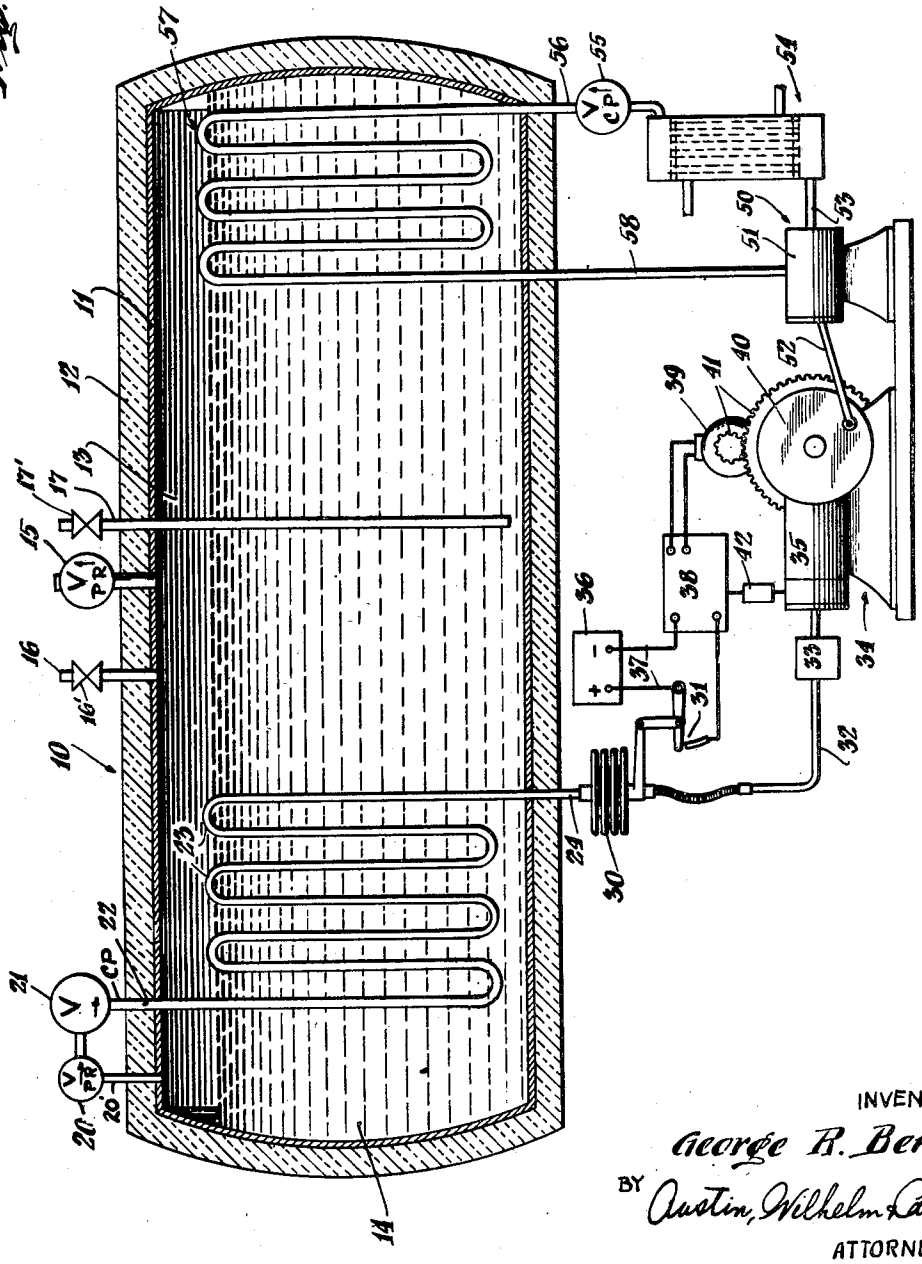
Jan. 16, 1951 G. R. BENZ 2,538,664

METHOD AND APPARATUS FOR SHIPPING AND STORING LIQUEFIED GASES

Filed May 24, 1946 2 Sheets-Sheet 1

Fig. 1



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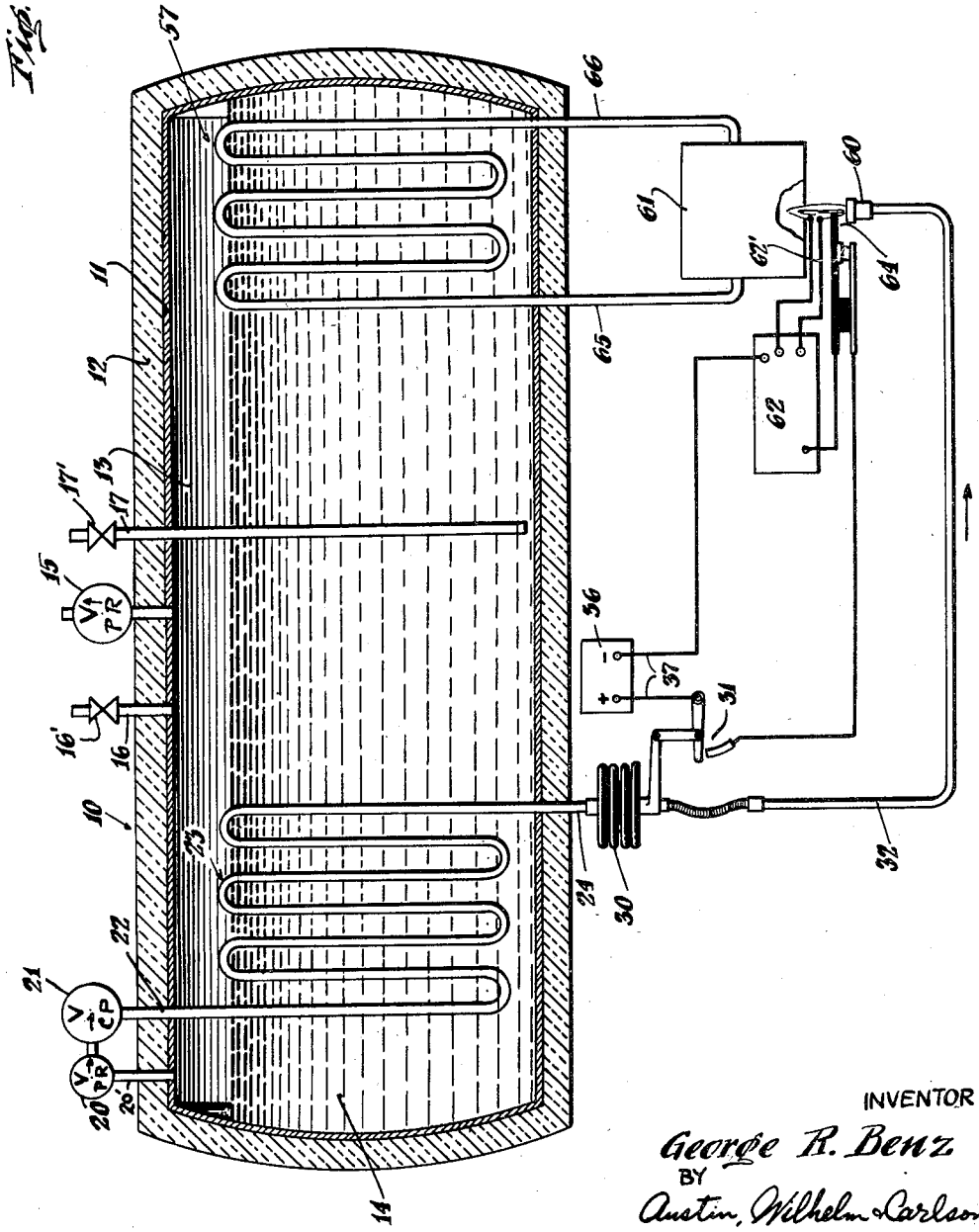
ATTORNEY

Jan. 16, 1951 G. R. BENZ 2,538,664

METHOD AND APPARATUS FOR SHIPPING AND STORING LIQUEFIED GASES

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Fig. 2



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UNITED STATES PATENT OFFICE

2,538,664

METHOD AND APPARATUS FOR SHIPPING AND STORING LIQUEFIED GASES

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Application May 24, 1946, Serial No. 672,141

21 Claims. (Cl. 62—1)

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This invention relates to an improved method and apparatus for shipping and storing liquefied gases and particularly liquefied gases such as methane, ethane and ethylene which develop a high vapor pressure under normal containing tank conditions.

Low vapor pressure hydrocarbons such as propane and butane are normally stored and shipped in pressure tanks or vessels in liquid condition. I now propose to store and ship high vapor pressure hydrocarbons such as methane, ethane, ethylene, as well, in liquid form. It is desirable to maintain such liquefied gases at a reasonably low temperature to avoid excessive evaporation and vapor pressure build-up within the tank or pressure vessel. While such tanks are often provided with an insulating jacket, the liquefied gas will nevertheless absorb atmospheric heat through the tank walls, creating pressure conditions which require the re'ease of pressure vapor from the tank if the tank structure is to be maintained within safe pressure limits.

It has been common practice to discharge these high pressure vapors from the tank to the atmosphere through a safety valve when the internal vapor pressure exceeds safe operating limits, as determined by engineering and insurance specifications. The loss of high pressure vapors through the safety valve constitutes a corresponding loss of valuable materials which becomes increasingly severe with every degree of rise in temperature of the tank contents.

As illustrative of the problem, ethane has a vapor pressure of 222 p. s. i. a. at 0° F., a vapor pressure of 350 p. s. i. a. at 32° F., and a vapor pressure of 506 p. s. i. a. at 60° F. Thus it is obvious that if a safe pressure condition is to be maintained, the internal temperature of the tank must be controlled so as to keep the vapor pressure of the liquid within the desired limits. In most climates the tank contents must be cooled by the use of refrigeration equipment associated with the tank, if vapor loss is to be kept down. No practical method or apparatus has heretofore been provided for refrigerating liquefied gas tanks moving in transit, such as tanks mounted on railroad cars or trucks, and as a result substantial and serious liquefied gas losses may be encountered by reason of the necessary release of high pressure vapors to the atmosphere.

In accordance with this invention, the vapor space within the tank is tapped and the high pressure vapors conducted to a pressure relief valve which opens only when the pressure in the tank vapor space exceeds a predetermined setting,

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say 200 p. s. i. g., which is below the setting of the tank safety valve. The pressure relief valve is designed to automatically open when the tank pressure exceeds a predetermined setting, and to automatically close when the pressure drops below a predetermined setting. The high pressure vapors which escape from the automatically opened pressure relief valve, flow to a constant pressure valve from which the vapors are conducted into a heat interchanger unit mounted in the tank and in heat exchange relationship to the body of liquefied gas. The constant pressure valve retains the vapor flowing from the valve to the heat interchanger unit at a substantially constant pressure of relatively low order, of say 0.5 p. s. i. g. The constant pressure valve is designed to automatically open just enough to maintain such constant pressure in the heat interchanger unit when the constant pressure valve is supplied with high pressure vapors escaping from the pressure relief valve. The reduction in vapor pressure effected by the constant pressure valve, permits expansion of the gas escaping therefrom. The expanding gas of reduced vapor pressure flowing from the constant pressure valve and through the heat interchanger unit, withdraws heat through the heat interchanger walls from the liquefied gas, and thus reduces the temperature of the liquid. The expanded low pressure vapor leaving the heat interchanger unit is conducted to a point external to the tank and used to provide the driving power necessary to operate a refrigeration unit. Thus the expanded gas vapor may be used to drive an internal combustion engine or gas motor which provides the power to operate the refrigeration unit, or the expanded gas may be burned and the heat generated used to operate a gas-flame type refrigeration unit.

The refrigeration unit is provided with a circulatory system through which a refrigerant, which may comprise ammonia, Freon, isobutane or the like, may circulate in a closed system. The circulatory system for the refrigerant includes a heat interchanger unit contained within the tank and in heat transfer relationship with the liquefied gas within the tank. The refrigerant circulating through the heat interchanger unit expands therein, and in expanding draws heat from the liquefied gas within the tank so as to further reduce the temperature thereof.

This invention therefore comprehends the provision of a dual-phase refrigeration system associated with a storage or shipping tank whereby the high pressure hydrocarbons or liquefied gas is first cooled by the expansion of the high pres-

sure vapors withdrawn from the tank, and further cooled by a refrigerant supplied by a refrigerating unit driven or operated by the expanded gas discharged from the first cooling phase.

Thus it will be appreciated that the high pressure vapors normally permitted to escape to the atmosphere, as is commonly done with liquefied CO_2 when shipped in tank cars, are used to provide dual-phase refrigeration of the liquefied gas without the consumption of other driving power. Apparatus to carry out this improved method may be simple in design and can advantageously be associated not only with stationary storage tanks, but tanks moving in transit.

Other objects and advantages of this invention will become apparent as the disclosure proceeds.

While the characteristic features of this invention will be particularly pointed out in the claims appended hereto, the invention itself and the manner in which it may be practiced, may be better understood by referring to the following description taken in connection with the accompanying drawings, forming a part thereof, in which

Fig. 1 is a diagrammatic illustration of a pressure tank containing liquefied gas of high vapor pressure characteristics, the tank having associated therewith a dual-phase refrigeration system, one phase of the cooling system being operated directly by the withdrawn high pressure vapors, the second phase of the cooling system comprising a refrigerating unit and circulatory system driven by a combustion engine powered by the expanded gases leaving the first phase of the refrigerating system; and

Fig. 2 is a diagrammatic illustration of a refrigerating system for a liquefied gas tank having a modified second phase cooling system in the form of a gas flame refrigeration unit powered by the gas vapor discharged from the first phase of the refrigeration system.

Similar reference characters refer to similar parts throughout the several views and drawings and specification.

There is diagrammatically illustrated in Fig. 1, a tank 10 of cylindrical form commonly used for the storage or transportation of liquefied gases. It will be appreciated however that this invention may be associated with any type or form of tank or pressure vessel. The usual gauging devices, sampling lines, thermometer wells, and the like, are not shown but may or may not be used as desired. Pressure tanks for storage or shipment of liquefied gases should be strongly constructed to provide a pressure shell 11 built up from steel plate and encased within an insulation covering 12.

In filling such pressure tanks with liquefied gas, vapor space 13 should be left above the body of liquefied gas 14 to provide a chamber for expansion and space for the gas which evaporates from the body of liquefied gas, if safe operating conditions are to be maintained. It is preferable to precool the liquefied gas before loading it into the tank. The pressure of the gas vapor in the vapor space 13 will of course depend upon the character of the liquefied gas and the temperature of the liquid and the tank interior, the pressure increasing proportionately with the rise in temperature of the liquid. Such tanks are built to safely withstand a certain interior pressure and safe operation requires that such tanks be equipped with a safety or pressure relief valve 15 to permit escape of vapors when the vapor pressure within the space 13 rises above a predetermined safe pressure. It has been customary to vent or discharge the excess high pressure vapors from the pressure relief valve 15 to the atmosphere, resulting in a corresponding loss of tank contents which is not recoverable. Hence it is highly desirable to keep the temperature within the tank at a point sufficiently low so that the corresponding vapor pressure of the material will not substantially exceed the pressure which the tank has been designed to withstand. The tank would ordinarily be equipped with a vapor line 16 having a flow control valve 16' and a liquid line 17 having a flow control valve 17' through which the gaseous or liquid materials are supplied to and withdrawn from the tank.

Transfer of atmospheric heat through the walls of the tank cannot be prevented completely by known methods of insulation, and therefore liquefied gas tanks used under normal climate conditions must either be strong and heavy to an impractical degree to resist the vaporization of the liquefied gas, or relief discharge of the pressure vapor must be provided, or refrigeration must be provided to maintain the interior of the tank at a temperature which will insure internal tank pressures not in excess of safe operating limits.

This invention comprehends the utilization of a dual-phase cooling system wherein the high pressure vapor is withdrawn from the tank through a vapor outlet 20' which leads from the vapor space 13 within the tank to an automatic pressure relief valve 20. The valve 20 has an opening and a closing setting which may be adjustably set as the particular operating condition requires. The opening setting is adjusted to prevent escape of vapor from the vapor space 13 until a certain predetermined maximum vapor pressure within the space is reached. When the vapor pressure build-up within the vapor space 13 has reached a predetermined maximum, the pressure relief valve 20 will automatically open, permitting high pressure vapor to flow through a constant pressure valve 21 and thence to flow at a constant pressure into the outlet conduit 22. The high pressure vapor continues to discharge from the pressure relief valve 20 until the vapor pressure in the vapor space 13 has been reduced to a predetermined minimum pressure, determined by the minimum pressure setting of the pressure relief valve 20, at which point the valve 20 will close.

Thus it will be appreciated that the pressure relief valve 20 is adjusted to maximum and minimum settings so as to open when the vapor pressure in the vapor space 13 has risen to a predetermined permitted maximum, and to close when the vapor pressure is reduced to a predetermined permitted minimum. By way of example, let us assume that for a specified tank, a vapor pressure within the tank must not be permitted to exceed 250 p. s. i. g. The automatic relief valve 20 might then be set to open at a maximum setting of 200 p. s. i. g. and set to close at a minimum setting of 150 p. s. i. g.

The constant pressure valve 21 may be set to open when high pressure vapor flowing from the pressure relief valve 20 is supplied thereto. The high pressure vapor is permitted to expand in flowing through the constant pressure valve 21, so that the vapor pressure of the vapor discharged into the outlet pipe 22 leading from the constant pressure valve 21 is of low order, and in the order of approximately 0.5 p. s. i. g. The expansion of

the vapor as it flows through the constant pressure valve 21 serves to reduce the temperature of the discharged low pressure vapor. This cold low pressure vapor is conducted by outlet pipe 22 to a heat interchanger unit 23 mounted in the tank and in heat interchange relation with the body of liquefied gas 14 therein. The heat interchanger unit 23 may be simple in design and may comprise a series of coil loops as shown in the drawings through which the cold low pressure vapor flows. The cold low pressure vapor in the coil loops withdraws heat from the liquefied gas body 14 and thus effects cooling of the liquefied gas body 14 in the tank.

The expanded vapor leaves the heat interchanger unit 23 at a pressure of approximately 0.5 p. s. i. g. and flows into a pipe 24 leading to a control bellows 30 exterior of the tank. The control bellows 30 may be of the Sylphon type designed to operate an electrical switch 31 for the purpose hereinafter described. The control bellows 30 operates to close the switch 31 when the vapor pressure supplied to the control bellows 30 is increased as a result of the vapor discharged from the constant pressure valve 21. When the pressure of the vapor flowing to the control bellows 30 is substantially reduced, or the vapor flow shut off by the closed pressure relief valve 20, the control bellows 30 opens the switch 31.

In the illustrative embodiment of the invention shown in Fig. 1, the heated and expanded gas vapor flowing from the control bellows 30 feeds into a gas line 32, into the carburator 33, and thence into the cylinder 35 of a gas engine 34. Power to provide starting torque and ignition for the gas engine 34 is furnished by a storage battery 36, the terminal lines 37 of which are connected in circuit to the electrical switch 31 manipulated by the control bellows 30.

When the circuit switch 31 is closed, current from the battery 36 is supplied to a starting and ignition unit 38. The starting and ignition unit 38 controls the current flow to a starter motor 39 which may be connected to the engine fly-wheel 40 by suitable power transmission gearing 41. The expanded gas and air mixture supplied by the carburator 33 to the gas engine cylinder 35 is ignited by a sparking device 42 which is electrically connected to the starting and ignition unit 38. The starting and ignition unit 38 may be of well known design, constructed to control the current flow to the sparking device 42 and to the starting motor 39. The starting motor 39 a'so has well known devices associated therewith for cutting off the current to the starting motor 39 and for disconnecting the motor gearing 41 from the engine fly wheel 40 when the fly wheel has attained a predetermined driven speed as driven by the action of the piston in the engine cylinder 35.

It will be appreciated that when the pressure relief valve 20 is automatically opened in response to tank pressure in excess of the predetermined maximum, pressure vapor is supplied to the constant pressure valve 21 at a pressure in excess of that desired to operate the power unit which drives the second phase refrigeration system. The constant pressure valve 21 performs the double function of permitting the vapor to expand, with resultant cooling thereof, and in addition reduces the pressure of the vapor supplied to the driving unit of the second phase refrigeration system to the desirable pressure.

The low pressure vapor supply to the control bellows 30 operates the bellows in a manner so that expansion of the bellows manipulates the switch 31 into closed position, thereby closing the electrical circuit between the current supply battery 36 and the starting and ignition unit 38. Both sparking ignition and motor starting torque will then be supplied, and the gas engine will be continuously driven by the expanded gas fed to the engine carburator 33 from the opened control valve associated with the control bellows 30.

When the pressure relief valve 20 cuts off the flow of vapor to the heat interchanger 23, the low pressure vapor to the control bellows 30 will also cease to flow, causing the control bellows to collapse and open the switch 31, thereby cutting off the supply of current from the battery 36 to the sparking and ignition unit 38.

It will be appreciated that this system could be operated by the elimination of the pressure relief valve 20, in which event the driving unit would continue in operation to drive the second phase refrigeration unit continuously until the tank was practically empty of liquefied gas and vapor. It is the preferably practice however, to provide the system with an automatic relief valve 20 which operates to shut off the vapor supply when the tank temperature has been reduced to the point where refrigeration is not required, and to automatically open the vapor lines when more refrigeration is needed.

From the above description it will be appreciated that the high pressure vapor which would normally be permitted to escape to the atmosphere is utilized for first phase cooling of the liquefied gas through the agency of the first heat interchanger unit 23, and the expanded gas vapor discharged from the heat interchanger unit 23 is additionally utilized to drive and operate the gas engine 34. The gas engine 34 may then be usefully employed to drive a compressor 50 forming a part of a second phase cooling system.

The compressor 50 may be of any well-known type having a compression cylinder 51 containing a piston having a suitable driving connection 52 with the gas engine 34. Refrigerant supplied to the compression cylinder 51, which may be of any desired type such as Freon, isobutane or ammonia, circulates in a closed system and therefore is not lost. The refrigerant, compressed and reduced to liquid form in the compression cylinder 51, flows through outlet pipe 53 into a cooling unit 54 of well known type to air cool the liquid refrigerant. The cooled liquid refrigerant flows from the cooler 54 through a constant pressure control valve 55 into a discharge line 56 which is in turn connected to a heat interchanger unit 57 in heat exchange contact with the body of liquefied gas 14 within the tank 10. The liquid refrigerant expands to vapor phase as it flows through the heat interchanger unit 57, heat for this purpose being drawn from the body of liquefied gas 14. The refrigerant in vapor phase leaves the heat interchanger unit 57 within the tank and is conducted through outlet pipe 58 to the compression cylinder 51 of the compressor 50. Thus it will be noted that the refrigerant is circulated through a closed system which embraces the heat interchanger unit 57, thereby providing a second phase cooling for the liquefied gas within the tank 10.

There is shown in Fig. 2 an adaptable and practical modification wherein the second phase cooling is carried out in a somewhat modified refrigeration system. More particularly, the expanded gas discharged from the control bellows 30 is conducted into discharge pipe 32 which leads

to a burner 60 associated with a gas type refrigeration unit 61 of well known design. The refrigeration unit 61 is connected to a heat interchanger 57 mounted within the tank by suitable conduits 65 and 66 to provide a closed circulatory circuit for the refrigerant.

Current spark to ignite the expanded gas discharged by the burner 60 is supplied by an ignition element 62' associated with an ignitor unit 62 having a circuit connection with the storage battery 36. A bimetallic thermal switch 64 is also associated with igniter unit 62 and operates when heated by the burner flame to cut off the current supply to the ignitor unit 62. Thus when the gas discharged from the burner 60 has been ignited to produce the required flame, the heat from the flame manipulates the thermal switch 64 which then in turn throws a switch associated with the ignitor unit 62 to render the same inactive so that battery current is not uselessly expended by the ignitor unit.

When the vapor pressure within the space 13 has been reduced, as a result of the dual phase cooling system constructed and operated as above described, to the point where the pressure relief valve 20 operates to cut off the supply of expanded gas to the control bellows 30, the bellows 30 will collapse, and in collapsing spring the switch 31 to cut off the current supply from the battery 36 to the ignitor unit 62. The collapsed bellows will also operate to cut off the supply of expanded gas to the burner 60, extinguishing the flame. The bimetallic thermal switch 64 will then cool and return to its normal position. When the flow of expanded gas through constant pressure valve 21 is resumed, the control bellows 30 will open to supply gas to the burner 60 and again close the battery switch 31 so that the ignitor 62 will be energized to ignite the flame, and as soon as the bimetallic thermal switch has again been heated to a predetermined degree by the flame, the thermal switch will de-energize the ignitor unit 62.

While the tank, in event of breakdown of the refrigeration system, is desirably supplied with a safety relieve valve 15 to permit the escape of vapor whose pressure is above the maximum pressure setting of the pressure relief valve 20 and near the maximum tank pressure permitted by applicable regulations, the apparatus lends itself to such sturdy construction that breakdown should be rare when periodic inspection and reasonable care of the equipment are provided.

This invention provides a method and apparatus whereby increased pressure produced by a rise in temperature of a liquefied gas contained in a tank or pressure vessel may be utilized for the purpose of cooling and refrigerating the liquid gas body within the tank in a dual phase cooling operation to effect rapid and economical cooling of the liquefied gas to well within safety pressure limits. The desired cooling is automatically controlled without manual attention or the supply of external power. A practical solution to the problem of cooling liquefied gases having a high vapor pressure so that they may be stored in a low pressure vessel is thus provided which insures practically no vapor loss to the atmosphere, and which insures highly efficient and rapid dual phase cooling automatically controlled by tank pressure conditions without manual attention and with a modest consumption of pressure gas.

This invention is usefully adapted for association with pressure tanks moving in transit and presents an economical and practical solution to the problem of transporting high vapor pressure hydrocarbons and liquefiable gases in low pressure containers which has confronted the industry for many years.

While certain novel features of the invention have been disclosed and are pointed out in the annexed claims, it will be understood that various omissions, substitutions and changes may be made by those skilled in the art without departing from the spirit of the invention.

What is claimed is:

1. An improved method for cooling a contained body of liquefied gas normally volatile under atmospheric temperatures and pressures which includes, conducting the pressure vapors released from the contained body of liquefied gas into indirect heat interchange relationship with the contained liquefied gas body under expansion conditions to effect cooling of the contained liquefied gas body, and removing the warmed vapor from heat interchange relationship with the contained liquefied gas body.

2. An improved apparatus for cooling tank contained liquefied gas of high vapor pressure to insure the retention of tank vapor pressures within safe operating limits which includes, a heat interchanger within the tank, a conduit connection for conducting pressure vapors from the tank interior to the circulatory system of said heat interchanger, a pressure relief valve for controlling the flow of vapor from the tank interior to said heat interchanger in accordance with variations in pressure within said tank, and a conduit extending from said heat interchanger to the tank exterior for discharging the expanded vapor from said heat interchanger.

3. An improved apparatus for cooling tank contained liquefied gas of high vapor pressure to insure the retention of tank vapor pressures within safe operating limits which includes, a heat interchanger unit within the tank, a conduit connection for conducting pressure vapors from the tank interior to the circulatory system of said heat interchanger unit, means in said conduit for controlling the expansion of the high pressure vapors withdrawn from the tank to supply cold low pressure vapor to the circulatory system of said heat interchanger unit, a gas powered refrigeration machine exterior to said tank, a second heat interchanger unit within said tank operatively connected to said refrigeration machine to provide a closed circulatory system through which a refrigerant may be circulated, and a conduit connection extending from said first heat interchanger unit to said refrigeration machine for supplying the low pressure vapor leaving said first heat interchanger unit to said gas powered refrigeration machine.

4. An improved apparatus for cooling tank contained liquefied hydrocarbons of high vapor pressure to insure the retention of tank vapor pressures within safe operating limits which includes, a heat interchanger unit within the tank, a conduit connection for conducting high pressure vapors from the tank interior to the circulatory system of said heat interchanger unit, a pressure relief valve for controlling the flow of gas vapor from the tank interior to said heat interchanger unit in accordance with variations in pressure within said tank, a gas powered refrigeration machine exterior to said tank, a second heat interchanger unit within said tank having a closed circulatory connection with said refrigeration machine through which a refrigerant may be circulated, a conduit connection extending from

said first heat interchanger unit to said refrigeration machine for supplying the warmed vapor leaving said first heat interchanger unit to said gas powered refrigeration machine, and means for automatically controlling the operation of said refrigeration machine in accordance with the flow of vapor thereto.

5. An improved apparatus for cooling high vapor pressure hydrocarbons contained within an enclosed tank to insure retention of tank pressures within safe operating limits which includes, a heat interchanger within the tank, a conduit connection for conducting high pressure vapors from the tank interior to the circulatory system of said heat interchanger, a pressure relief valve in said conduit for controlling the flow of gas vapor from the tank interior, a constant pressure control valve in said conduit operative to permit expansion of the high pressure vapors discharged from said relief valve and discharge thereof into said circulatory system in cold condition and at substantially reduced pressure, a refrigeration unit exterior to the tank designed to utilize gas vapor as its operating energy, a second heat interchanger within said tank, a conduit system joining said refrigeration unit and second heat interchanger to provide an enclosed system through which a refrigerant may be circulated, a conduit for conducting the warmed low pressure vapor leaving said first heat interchanger to said gas powered refrigeration unit, a flow operated device associated with said conduit connection, and electrical means operatively connected to said flow operated device for automatically controlling the operation of said refrigeration unit in accordance with the vapor flow through said flow operated device.

6. An improved apparatus for cooling high vapor pressure hydrocarbons contained within an enclosed tank to insure retention of tank pressures within safe operating limits which includes, a heat interchanger within the tank, a conduit connection for conducting high pressure vapors from the tank interior to the circulatory system of said heat interchanger, a pressure relief valve for controlling the flow of gas vapor from the tank interior in accordance with variations in pressure within said tank, a constant pressure control valve in said conduit operative to permit expansion of the high pressure vapors discharged from said relief valve and discharge thereof into said circulatory system in cold condition and at substantially reduced pressure, a refrigerant compressor, a driving engine therefore designed to utilize gas as its operating energy, a second heat interchanger within said tank, a conduit system connecting said refrigerant compressor to said second heat interchanger to provide an enclosed system through which a refrigerant may be circulated, a conduit for conducting the warmed low pressure vapor leaving said first heat interchanger to said gas powered driving engine, a flow operated device associated with said conduit connection, a storage battery, a starting and ignition unit having circuit connection with said storage battery, a circuit switch operably connected to said flow operated device for controlling the current flow from said battery to said starting and ignition unit in accordance with the flow of vapor through said flow control device, a sparking device associated with said gas engine controlled by said starting and ignition unit, and a starting unit for said engine controlled by said starting and ignition unit.

7. An improved apparatus for cooling high vapor pressure hydrocarbons contained within an enclosed tank to insure retention of tank pressures within safe operating limits which includes, a heat interchanger within the tank, a conduit connection for conducting high pressure gas vapors from the tank interior to the circulatory system of said interchanger, a pressure relief valve for controlling the flow of vapor from the tank interior to said heat interchanger in accordance with variations in pressure within said tank, a constant pressure control valve in said conduit operative to permit expansion of the high pressure vapors discharged from said relief valve and discharge thereof into said circulatory system in cold condition and at substantially reduced pressure, a gas type refrigeration unit exterior to the tank having a gas burner designed to utilize vapor to operate the unit, a second heat interchanger within said tank, a conduit system connecting said refrigeration unit to said second heat interchanger to provide an enclosed system through which a refrigerant may be circulated, a conduit for conducting the warmed low pressure vapor leaving said first heat interchanger to said gas burner, a flow operated device associated with said conduit connection, a storage battery, an igniter having a circuit connection with said storage battery, a circuit switch operably connected to said flow operated device for controlling the current flow from said battery to said igniter in accordance with the flow of vapor through said flow operated device, and a thermal element in said battery circuit positioned to be heated by the gas flame produced by the gas burner to control the flow of battery current to said igniter.

8. An improved apparatus for cooling tank contained liquefied gas of high vapor pressure to insure the retention of tank vapor pressures within safe operating limits which includes, a conduit connection for conducting pressure vapors from the tank interior, means in said conduit for controlling the expansion of high pressure vapors withdrawn from the tank to provide a supply of low pressure vapors, a gas powered refrigeration machine connected to said low pressure vapor supply, and a heat interchanger unit within said tank operably connected to said refrigeration machine to provide a closed circulatory system through which a refrigerant may be circulated.

9. An improved apparatus for cooling tank contained liquefied hydrocarbons of high vapor pressure to insure the retention of tank vapor pressures within safe operating limits which includes, a conduit connection for conducting high pressure vapors from the tank interior, a pressure release valve for controlling the flow of gas vapor from the tank interior in accordance with variations of pressure within said tank, a gas powered refrigeration machine connected to the low pressure side of said pressure release valve, a heat interchanger unit within said tank having a closed circulatory connection with said refrigeration machine through which a refrigerant may be circulated, and means for automatically controlling the operation of the machine in accordance with the flow of the vapor thereto.

10. An improved apparatus for cooling high vapor pressure hydrocarbons contained within an enclosed tank to insure retention of tank pressures within safe operating limits which includes, a conduit connection for conducting high pressure vapors from the tank interior, a pres-

sure release valve in said conduit for controlling the flow of gas vapor from the tank interior, a constant pressure control valve in said conduit operative to permit expansion of high pressure vapors discharged from said release valve at substantially reduced pressure, a refrigeration unit connected to the low pressure side of said pressure control valve and designed to utilize gas vapor as its operating energy, a heat interchanger within said tank, a conduit system joining said refrigeration unit and heat interchanger to provide an enclosed system through which a refrigerant may be circulated, a flow operated device through which the low pressure gas is supplied to said refrigeration unit, and electrical means for automatically controlling the operation of said refrigeration unit in accordance with the vapor flow through said flow operative device.

11. An improved method for cooling a contained body of liquefied gas normally volatile under atmospheric temperatures and pressures which includes, withdrawing high pressure vapor released from the contained body of liquefied gas, cooling the withdrawn vapor by subjecting the same to expansion conditions, conducting the expanding vapor into heat interchange relationship with the liquefied gas body to thereby effect cooling of the liquified gas body, removing the warmed vapor from heat interchange relationship with the liquefied gas body, and automatically controlling the withdrawal of the high pressure vapor in accordance with the existing vapor pressure overlying the contained body of liquefied gas.

12. An improved method for cooling tank contained liquefied gases normally volatile under atmospheric temperatures and pressures which includes, conducting the pressure vapor released from the contained body of liquefied gas into indirect heat interchange relationship with the contained liquefied gas body to thereby effect cooling of the liquefied gas body, removing the warmed vapor from heat interchange relationship with the liquefied gas body, and automatically controlling the withdrawal of high pressure vapor from the tank in accordance with the existing pressure conditions in the tank.

13. An improved method for cooling tank contained liquefied gas normally volatile under atmospheric temperatures and pressures which includes, withdrawing pressure vapor released from the body of contained liquefied gas, controlling the withdrawal of the pressure vapor in accordance with the predetermined pressure conditions in the tank, cooling the withdrawn vapor by subjecting same to expansion conditions, conducting the expanding vapor into heat interchange relationship with the liquefied gas body to thereby withdraw sensible heat from the liquefied gas body, withdrawing the warmed low pressure vapor from the tank, and utilizing the withdrawn low pressure vapor as a supply of power.

14. An improved method for cooling tank contained liquefied gas normally volatile under atmospheric temperatures and pressures which includes, withdrawing high pressure vapor released from the body of contained liquefied gas, controlling the withdrawal of the high pressure vapor in accordance with the existing pressure conditions in the tank, cooling the withdrawn vapor by subjecting same to expansion conditions, conducting the cooled vapor into indirect heat interchange relationship with the liquefied gas body to cool the contained body of liquefied gas, maintaining the conducted vapor at a substantially constant low pressure, withdrawing the warmed low pressure vapor from the tank, and utilizing the withdrawn low pressure vapor as a supply of power to operate an additional cooling system.

15. An improved method for cooling tank contained liquefied gas normally volatile under atmospheric temperatures and pressures which includes, maintaining a body of released vapor under pressure over the body of contained liquefied gas, withdrawing vapor under pressure from said body of vapor, cooling the withdrawn vapor by subjecting the same to expansion conditions, conducting the cooled vapor into indirect heat interchange relationship with the liquefied gas body to cool the contained body of liquefied gas, withdrawing the warmed low pressure vapor from the tank, and utilizing the withdrawn low pressure vapor as a supply of power to operate an additional self contained refrigeration system for further cooling the contained body of liquefied gas.

16. An improved method for cooling liquid hydrocarbons normally volatile under atmospheric temperatures and pressures and contained within an enclosed tank to insure the retention of pressure within the tank within safe operating limits which includes, circulating a cooling refrigerant in a closed system in indirect heat interchange relationship with the contained liquid body to withdraw sensible heat from the contained liquid body and thereby effect cooling thereof and a corresponding reduction of vapor pressure within the tank, utilizing the vapor withdrawn from the tank to supply the driving power for the refrigerant circulating system, and controlling the operation of the refrigerant circulating system in accordance with the variations in pressure of the tank contained pressure vapor.

17. An improved method for cooling liquid hydrocarbons normally volatile under atmospheric temperatures and pressures and contained within an enclosed transportation tank to insure the retention of vapor pressures within the tank within safe operating limits which includes, maintaining a body of released vapor under pressure over the body of contained liquefied gas, withdrawing vapor under pressure from said body of vapor, circulating a cooling refrigerant through a closed refrigeration system in indirect heat exchange relationship with the contained liquid body to withdraw sensible heat from the contained liquid body and thereby effect cooling thereof and a corresponding reduction of vapor pressure within the tank, utilizing the vapor withdrawn from the tank to supply the driving power for the refrigeration circulating system, and automatically controlling the operation of the refrigeration system in accordance with variations in pressure of the tank contained vapor.

18. An improved method for cooling liquid hydrocarbons normally volatile under atmospheric temperatures and pressures and contained within an enclosed transportation tank to insure the retention of vapor pressures within the tank within safe operating limits which includes, circulating a cooling refrigerant through a closed refrigeration system in indirect heat interchange relationship with the contained liquid body to withdraw sensible heat from the contained liquid body and thereby effect cooling thereof and a corresponding reduction of vapor

pressure within the tank, utilizing the vapor withdrawn from the tank to supply the power to drive the refrigeration circulating system, automatically controlling the withdrawal of high pressure vapor from the tank in accordance with variations in pressure of the contained pressure vapor, and automatically controlling the starting up and shutting down of the refrigeration system in accordance with the flow of the vapor thereto.

19. An improved method for cooling liquefied gas normally volatile under atmospheric temperatures and pressures and contained within an enclosed tank to insure the retention of vapor pressures within safe operating limits which includes, conducting the vapor released from the contained body of liquefied gas through a first cooling system in indirect heat interchange relationship with the contained liquefied gas body to thereby effect cooling of the tank contained liquefied gas, controlling the withdrawal of the high pressure vapor from the tank in accordance with changes in pressure of the tank contained vapor, circulating a refrigerant contained within a second cooling system in heat interchange relationship with the contained liquid body to thereby effect further cooling thereof, and utilizing the low pressure gas vapor withdrawn from the first cooling system as a source of operating power for the second cooling system.

20. An improved method for cooling liquefied gas normally volatile under atmospheric temperatures and pressures and contained within an enclosed tank to insure the retention of vapor pressures within safe operating limits which includes, withdrawing the high pressure vapor from the tank, cooling the withdrawn high pressure vapor by subjecting the same to expansion conditions, conducting the cooled vapor through a first cooling system in indirect heat interchange relationship with the contained liquefied gas to thereby effect cooling of the liquefied gas body, removing the warmed low pressure vapor from heat interchange relationship with the liquefied gas body, circulating a refrigerant contained within a second cooling system in heat interchange relationship with the contained liquefied gas to thereby effect further cooling thereof, and utilizing the low pressure gas vapor withdrawn from the first cooling system as a source of operating power for the second cooling system.

21. An improved method for cooling liquid hydrocarbons normally volatile under atmospheric temperatures and pressures and contained within a transporation tank to insure the retention of vapor pressures within safe operating limits which includes, withdrawing the high pressure vapor from the tank, conducting the withdrawn vapor through a first cooling system in indirect heat interchange relationship with the contained liquid body under expansion conditions to thereby effect cooling of the hydrocarbon liquid, removing the warmed low pressure vapor from heat interchange relationship with the liquid body, circulating a refrigerant contained within a second cooling system in heat interchange relationship with the contained liquid body to thereby effect further cooling thereof, and utilizing the low pressure vapor withdrawn from the first cooling system as a source of operating power for said second cooling system.

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