Feb. 26, 1952 D. MAPES 2,586,839

PURGING APPARATUS FOR FUEL STORAGE SPACES AND THE LIKE

Filed Dec. 17, 1948

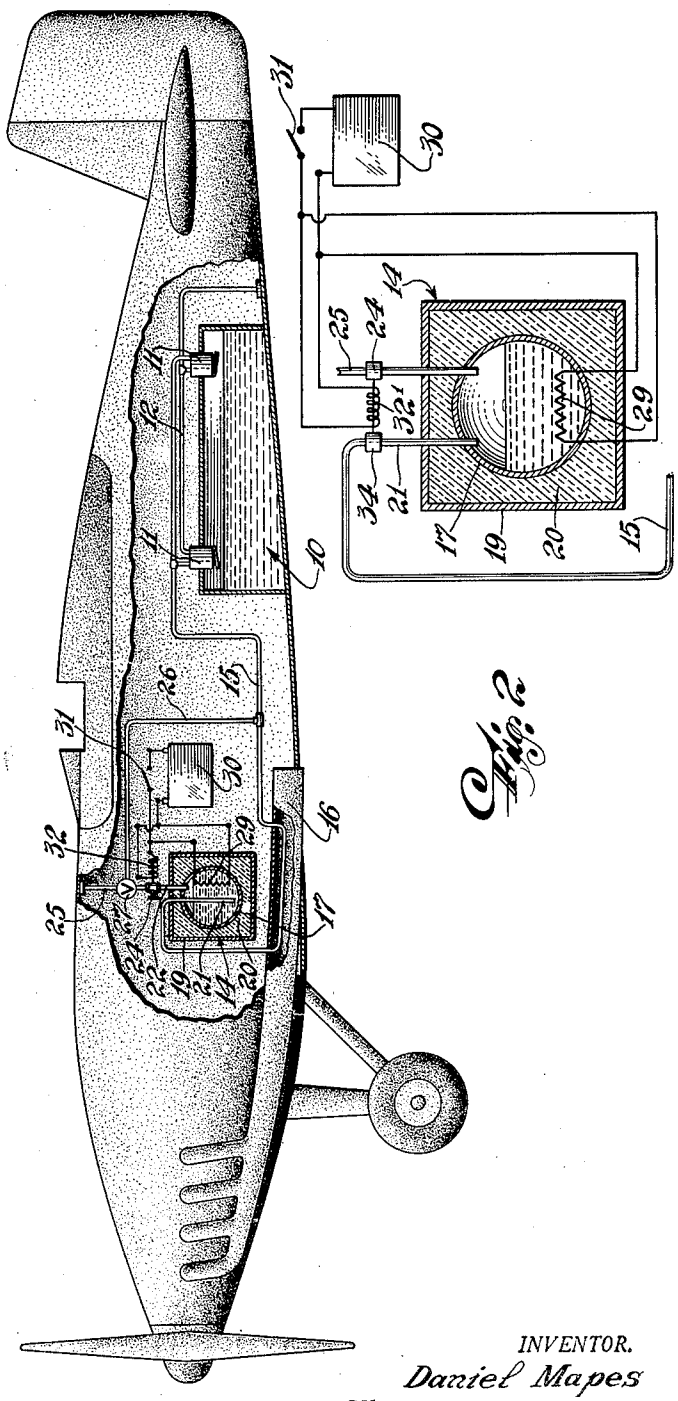


Fig. 1

Fig. 2

INVENTOR.
Daniel Mapes
BY
J. William Carson
ATTORNEY

Patented Feb. 26, 1952

2,586,839

UNITED STATES PATENT OFFICE

2,586,839

PURGING APPARATUS FOR FUEL STORAGE SPACES AND THE LIKE

Daniel Mapes, West Caldwell, N. J., assignor to Specialties Development Corporation, Belleville, N. J., a corporation of New Jersey

Application December 17, 1948, Serial No. 65,962

8 Claims. (Cl. 220—88)

1

The present invention relates to apparatus for purging spaces in which an explosive vapor mixture may exist, and more particularly to such apparatus for purging spaces at temperatures as low as —40° F. at any atmospheric pressure.

It has been customary to purge gasoline tanks, fuel cells, and other similar compartments or spaces of aircraft and the like, or to dilute fuel vapors therein with a non-combustion supporting gas in order to prevent explosions which otherwise might take place if these spaces were pierced by a projectile during combat or were subjected to flame or spark in the event of crash or collision.

Heretofore, various methods have been used to accomplish the foregoing but none have been found to be particularly satisfactory. One of the best known methods has been to introduce carbon dioxide gas into the space in which an explosive vapor mixture might exist. However, the storage of carbon dioxide in highly compressed or liquid form requires the use of heavy and bulky containers, known as cylinders, which are objectionable due to their excessive weight. Furthermore, liquid carbon dioxide when expanded into the atmosphere or into spaces under atmospheric pressure at low temperatures such as encountered at high altitudes forms snow particles and is therefore not effective as a purging medium.

It has also been proposed to utilize the exhaust gases of engines but this has led to serious objections because of the unduly heavy, space consuming and complicated apparatus required to remove water vapor, which otherwise would ice-up tanks and supply lines, and required to remove highly corrosive gases in the exhaust, such as oxides of nitrogen, which would have a highly corrosive effect on the fuel supply system and a toxic effect on persons.

The present invention aims to overcome the foregoing difficulties and objections.

Accordingly, an object of the present invention is to provide an efficient, lightweight, compact system for purging spaces at low temperatures in which explosive vapor mixtures may exist.

Another object is to provide apparatus which is simple in construction and can be economically manufactured and operated.

Another object is to provide such apparatus

2

which is readily adapted for manual or automatic operation.

Another object is to provide a purging system wherein purging substances are utilized which can be stored in liquid state at low pressures and can exist in vapor state at low temperatures while at atmospheric pressures.

A further object is to provide an improved manner of purging spaces in which explosive vapor mixtures may exist.

Other and further objects of the invention will be obvious upon an understanding of the illustrative embodiment about to be described, or will be indicated in the appended claims, and various advantages not referred to herein will occur to one skilled in the art upon employment of the invention in practice.

In accordance with the invention, the foregoing objects are accomplished by providing a system generally comprising a source of a purging substance which can be stored in liquid state at low pressure and can exist in vapor state at low temperatures while at atmospheric pressures, and means for vaporizing the substance and conducting the same from the source to the space to be purged. The substance in liquid state may be vaporized in any suitable manner. For example, this may be accomplished by the application of external heat at the source to vaporize portions of the substance and induce the flow thereof to the space, or alternately or conjunctively by the application of external heat to liquefied and/or vaporized portions of the substance in the conducting means (introduced from the source) to induce the flow thereof in vapor state to the space. The source may further be provided with venting means for preventing the building up of excessive pressures therein. Such venting means may be operatively associated with means for controlling the flow of the substance from the source in a manner to substantially simultaneously render the venting means ineffective upon actuation of the flow controlling means.

By the term "low temperature purging substance" as used herein and in the appended claims, is meant a substance which can be confined in liquid state without exhibiting any tendency to solidify at pressures less than 75 pounds per square inch absolute, preferably at pressures less than 5 pounds per square inch absolute un-

der the conditions of storage described hereinafter, and which can exist in vapor state at temperatures lower than —40° F. while at atmospheric pressures at all altitudes.

In the following table, examples of such substances are given together with pertinent physical data concerning the same:

Substance	Formula	Boiling Pt. at 14.7 lbs./sq. in.	Latent Heat B. t. u./lb.
		°F.	
Nitrogen	N_2	—319	90
Neon	Ne	—398	56
Perfluoromethane	CF_4	—198	60
Fluoroform	CF_3H	—116	111
Monochlorotrifluoromethane	$CClF_3$	—112	61
Perfluoroethane	C_2F_6	—108.8	
Perfluorodimethyl ether	C_2F_6O	—74	
Monochlorodifluoromethane	$CHClF_2$	—42	101

These substances are stable, non-flammable, non-corrosive, non-toxic, provide an excellent inerting atmosphere; do not decompose into toxic materials when subjected to heat; and have a latent heat of a value which enables conversion from liquid to vapor state in a rapid and convenient manner.

Of these substances, nitrogen is preferred because of its relatively low cost, general availability and its chemical inertness and its inability to decompose.

At reduced atmospheric pressure conditions, such as exist at altitudes above sea level, the boiling point of these substances is lowered, thereby enabling a substance such as monochlorodifluoromethane to be vaporized and used to good advantage, even when subjected to the atmospheric temperatures at such altitudes. In the following table, there is given the atmospheric pressure in pounds per square inch absolute and the extreme temperature at various altitudes together with the approximate boiling point of monochlorodifluoromethane at such altitudes.

Altitude	Pressure	Temperature [1]	Boiling Point
Feet	*Lbs./sq. in.*	°F.	°F.
2,500	13.4	50	—44
5,000	12.2	41.2	—48
10,000	10.1	25.2	—52
20,000	6.75	—12.3	—64
30,000	4.35	—47.9	—80
40,000	2.71	—67.0	—94
50,000	1.69	—67.0	—107
80,000	.40	—67.0	—140

[1] Air temperature when ground temperature is 59° F.

This serves to illustrate that the materials listed herein are capable of being utilized as a gaseous purging medium at temperatures as low as —40° F., and at even lower temperatures at above sea level pressures, because the boiling points of the materials are lower than —40° F., thereby enabling the materials to be conducted into the space to be purged and maintained therein in vapor state without danger of condensing.

The materials listed herein are also capable of being utilized as a gaseous purging medium at —40° F. at below sea level atmospheric pressures, as illustrated in the following table:

Altitude	Pressure	Boiling Point [1]
Feet	*Lbs./sq. in.*	°F.
—1,000	15.2	—40
—500	14.9	—41

[1] Monochlorodifluoromethane.

In the drawing:

Figure 1 is a schematic view, partly in elevation and partly in section, illustrating an airplane embodying a system in accordance with the present invention.

Figure 2 is a fragmentary schematic view, illustrating modified apparatus for use in connection with the system shown in Figure 1.

Referring to the drawing in detail, and more particularly to Figure 1, there is shown an airplane having a fuel tank **10** in its fuselage, which, by way of example, illustrates more or less schematically a space or compartment of the type requiring purging or inerting thereof to prevent explosion. Usually, as shown, such tanks or spaces are equipped with fittings **11** in the vapor space thereof connected to a conduit **12** for normally venting fuel vapors to the atmosphere and for introducing the medium for purging the explosive mixture upon operation of the system about to be described.

The purging or inerting system generally comprises a source of low temperature purging substance in liquid state as indicated at **14**, and a conduit **15** connecting the source to the interior of the tank **10**, preferably at the vapor space thereof.

The conduit **15** serves as means for dispensing liquid substance from the source, means in which the liquid substance is vaporized by being in heat exchange relation with a warmer body, and means for conducting the vaporized substance to the tank. For purpose of illustration, heat is supplied to the conduit to vaporize liquid substance therein by passing a section of the conduit through the engine exhaust manifold **16**.

It will be understood that this section of the conduit **15** may be of any desired length, may be in the form of a coil, or may be provided with fins or the like for effecting more efficient heat exchange. It will also be apparent, that an independently operated heat source could be associated with the conduit or that the conduit could be exposed or subjected to a supply of atmospheric air serving as a supply of heat. Such equivalents do not appear to warrant illustration and detailed description, because they are well known to those skilled in the art.

The source of liquid purging substance preferably comprises a lightweight, thin-walled container, such as a sphere **17**, constructed of a suitable material having a low heat conductivity, for example, stainless steel of the nickel-chromium type, and a housing **19** containing insulating material **20**, for example of the silica aerogel type. In this manner, the liquid substance is adapted to be stored at a low temperature and at a low pressure while protected against the inflow of heat. For example, storage means of this type are adapted to confine liquefied substances of the type described herein at temperatures ranging between about —40° and —400° F. while under a positive pressure of less than about one pound per square inch absolute. As shown, the conduit **15** is connected to the upper end of the sphere **17** and a section **21** of the conduit **15** extends to the bottom of the interior of the sphere and serves as a syphon or eduction tube for the source.

In order to prevent the building up of pressures within the sphere higher than desired, a conduit **22** is connected to the upper end thereof which has a vent valve **24** therein constructed and arranged for normally venting the sphere. If desired, the sphere may be vented to the atmos-

sphere by a conduit 25 or may be by-passed by a conduit 26 into the conduit 15 or conducted directly into the tank 10 to utilize the vented vapors of the substance for intermittently providing a mild inerting atmosphere in the tank 10, whereby the purging substance is used to its full advantage and is not wasted. The choice of venting to the atmosphere or by-passing to the conduit 15 may be controlled by a selector valve 27 connecting the conduits 25 and 26.

The source of liquid purging substance is further provided with means for inducing the flow of liquid therefrom by way of the tube section 21 of the conduit. Such means, as illustrated, may be an electrical heating element 29 disposed within the sphere 17, which creates pressure therein, on the order of about two pounds, by warming up the substance and causing the pressure head to force liquid into the conduit 15. The heating element is connected in an electrical circuit including a battery 30 or other source of electrical energy and a switch 31 for controlling the circuit. It will be understood that the heating means may be in the form of a heat exchanger through which engine exhaust gases or other heat exchange medium may be conducted at desired instances to heat the liquid and create the necessary pressure to induce the flow of liquid from the source. Likewise, other types of pressure producing means could be utilized, for example, a source of fluid pressure medium could be introduced into the upper end of the sphere to discharge liquid therefrom. Also, a suitable mechanical pump could be used for forcing or withdrawing liquid from the sphere.

In order to prevent the escape of purging substance by way of the vent valve 24 while the heating element 29 is operative, the vent valve is under the control of a solenoid 32, or the like, which is connected in the circuit to be energized upon closing of the switch 31 and is adapted to render the vent valve ineffective by maintaining it in a closed position.

In operation, a supply of liquid low temperature purging substance is placed in the sphere, or container 17 of the source and is stored therein. Due to slight heat leakage into the sphere, the pressure therein increases slightly but is relieved by way of the vent valve, which, upon opening, permits slight expansion in the sphere to produce a refrigerating effect. As mentioned previously herein, the vented substance may be conducted to the atmosphere or may be conducted to the tank or space to be purged, thus mildly diluting the fuel vapors from time to time to render them less explosive.

In the event it is desired to purge the tank, the switch 31 is closed, thereby connecting the heating element 29 to the battery 30 and substantially simultaneously effecting energization of the solenoid 32 to close the valve 24. As the liquid substance is warmed up, portions thereof are discharged into the conduit 15 and are conducted to the section in heat exchange relation with a warmer body to effect vaporization thereof. The vaporized substance is then conducted to the tank and introduced therein to purge the vapor space therein or greatly dilute the fuel vapors with inert gas to provide a non-explosive or non-combustible mixture.

After the tank has been purged, the switch 31 is opened to disconnect the heating element 29 and to deenergize the solenoid, whereby the valve 24 is again conditioned for venting the sphere.

Referring now to Figure 2, there is shown modified apparatus for use in connection with the system shown in Figure 1 wherein the liquid purging substance is vaporized at the source when desired for purging the space.

This apparatus differs essentially from the apparatus previously described with reference to Figure 1 in that the section 21 of the conduit 15 extends only into the vapor space of the container 17, instead of into the liquid, to thereby serve to conduct vaporized substance from the container. In this embodiment, the heating element 29 serves to vaporize the liquid.

Further, a flow control valve 34 is provided in the conduit 15 adjacent the section 21 thereof for rendering the flow of vaporized substance to the space to be purged effective and ineffective at will. Preferably, the valve 34 is normally closed and is constructed and arranged to be opened at such times when the liquid is vaporized by the heating element 29. This may be accomplished by operatively associating the valve with a solenoid in circuit and under the control of the switch 31. For example, a single solenoid 32' may be utilized to open the valve 34 and simultaneously close the vent valve 24 upon energizing the circuit to render the heating element operative.

It will be appreciated that the vapor removed from the container 17 could be conducted directly to the space to be purged or could be heated further by means of a heat exchanger, such as the exhaust manifold 16, to increase its pressure and further induce its flow to the space.

Also, it will be understood that the heating element 29 could be in the form of a heat exchanger through which engine exhaust gas or other heat exchange medium could be conducted upon opening of the valve 34 to thereby heat the liquid and vaporize portions thereof, the vapor being then conducted to the space to be purged.

While the present invention has been illustrated and described in connection with a gas tank for an airplane, it will be understood that it may be advantageously employed for inerting spaces of all kinds on airplanes, speedboats, combat tanks and other vehicles or craft, and stationary structures.

From the foregoing description, it will be seen that the present invention provides an improved system for inerting spaces in which an explosive vapor mixture may exist. The system is simple, practical and economical in operation, is extremely light in weight and does not occupy much space in relation to the large volume of inert gas dispensed by it.

As various changes may be made in the form, construction and arrangement of the parts herein, without departing from the spirit and scope of the invention and without sacrificing any of its advantages, it is to be understood that all matter herein is to be interpreted as illustrative and not in any limiting sense.

It is also to be understood that the following claims are intended to cover all the generic and specific features of the invention herein described, and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

I claim:

1. In a system for purging spaces in which an explosive vapor mixture may exist, the combination of a source of low temperature purging substance in liquid state, conduit means connecting the space to said source, and means in heat exchange relation with said conduit means for va-

porizing the liquid substance during its passage from said source to the space.

2. In a system for purging fuel supply means, the combination of a fluid fuel storage tank, a container for storing a low temperature purging substance in liquid state, a conduit connecting said tank and said container, and means in heat exchange relation with said conduit for supplying heat thereto to effect vaporization of the liquid substance in said conduit.

3. In a system for purging spaces in which an explosive vapor mixture may exist, the combination of a source of low temperature purging substance in liquid state, conduit means connecting the space to said source, means associated with said source for inducing the flow of liquid substance from said source into said conduit means, and means in heat exchange relation with said conduit means for vaporizing the liquid substance during its passage from said source to the space.

4. In a system for purging fuel supply means, the combination of a fluid fuel storage tank, an insulated container for storing a low temperature purging substance in liquid state, a conduit connecting said tank and said container, a heating element in said container for inducing the flow of liquid substance from said container into said conduit, and means in heat exchange relation with said conduit for supplying heat thereto to effect vaporization of liquid substance in said conduit.

5. In a system for purging fuel supply means, the combination of a fluid fuel storage tank, an insulated container having a vent valve and being adapted for storing a vaporizable purging substance at a low temperature, a conduit connecting said tank and said container, an electrical heating element in said container for inducing the flow of purging substance from said container into said conduit, means in heat exchange relation with said conduit for supplying heat thereto to effect vaporization of purging substance in said conduit, a solenoid operable to effect closing of said vent valve, and an electrical circuit including a switch and a source of electrical energy for simultaneously rendering said heating element and said solenoid operable.

6. In a system for purging fuel supply means, the combination of a fluid fuel storage tank, an insulated container for storing a low temperature purging substance in liquid state, a conduit connecting said tank and the lower portion of said container, a second conduit connecting the upper portion of said container to the atmosphere, a vent valve in said second conduit, an electrical heating element in said container for inducing the flow of liquid substance from said container into said conduit, means in heat exchange relation with said conduit for supplying heat thereto to effect vaporization of liquid substance in said conduit, a solenoid operable to effect closing of

said vent valve, an electrical circuit including a switch and a source of electrical energy for simultaneously rendering said heating element and said solenoid operable, a second valve having an inlet and an outlet connected in said second conduit and a by-pass outlet, and conduit means connecting said by-pass outlet and said tank, said second valve being operable to selectively direct the flow of substance from the upper portion of said container to said tank or the atmosphere.

7. In a system for purging spaces in which an explosive vapor mixture may exist, the combination of a heat insulated container having a normally open vent valve and being adapted for storing a vaporizable purging substance at a low temperature, a conduit connected to said container for conducting the purging substance from said container to the space to be purged, electrical heating means for said container for inducing the flow of purging substance from said container into said conduit, a solenoid operable to effect closing of said vent valve, and an electrical circuit including a switch and a source of electrical energy connected with said heating means and said solenoid for simultaneously rendering said heating element and said solenoid operable.

8. In a system for purging spaces in which an explosive vapor mixture may exist, the combination of a container for storing a vaporizable purging substance at a low temperature, a conduit connected to said container for establishing fluid flow communication between said container and the space to be purged, means associated with said container for inducing the flow of purging substance from said container into said conduit, a second conduit connected to said container for establishing fluid flow communication between the upper interior zone of said container and the space to be purged, and a valve in said second conduit for controlling the flow of purging substance therethrough, said valve having a venting outlet and being operable for selectively controlling the flow of purging substance to the space to be purged or to said venting outlet.

DANIEL MAPES.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,153,555	Gallery	Apr. 11, 1939
2,375,834	Walker	May 15, 1945
2,406,373	Heigis	Aug. 27, 1946

FOREIGN PATENTS

Number	Country	Date
529,635	Great Britain	Nov. 26, 1940