

[54] LIQUEFIED GAS CONTAINERS

[76] Inventor: **Peter Jones**, 2211 Verde Oake Dr.,
Hollywood, Calif. 90028

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[58] Field of Search..... **220/9 B, 9 LG, 22,**
220/15; 62/45, 514

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Primary Examiner—Meyer Perlin

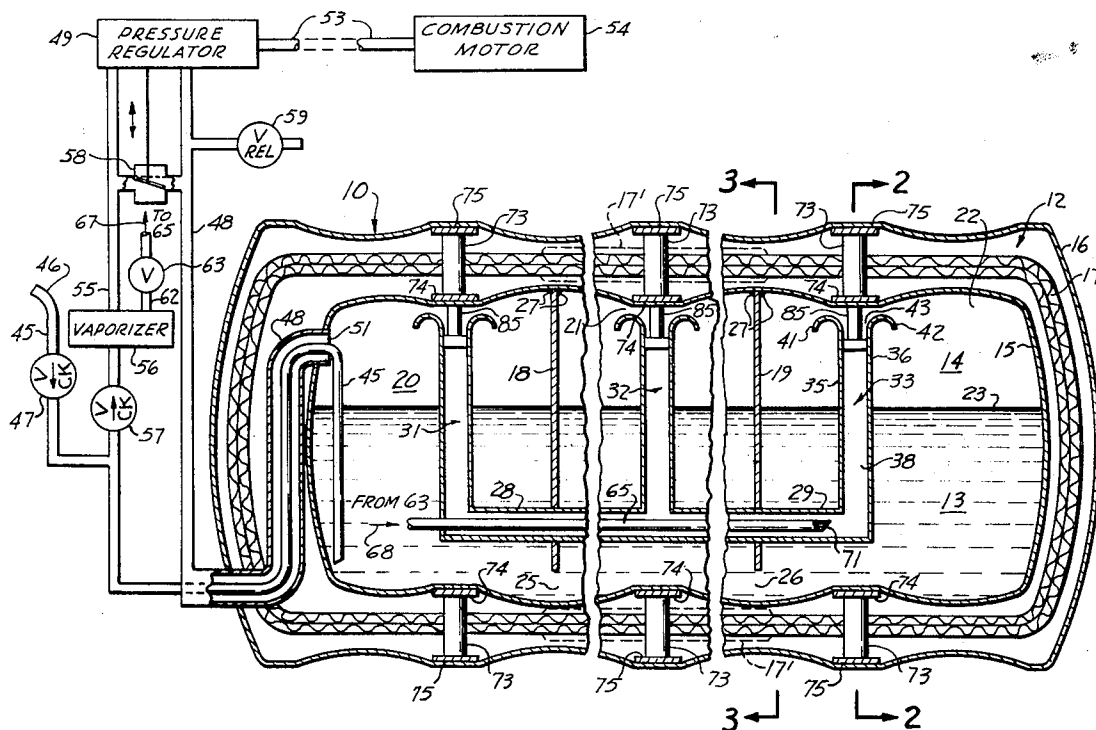
Assistant Examiner—Ronald C. Capossela

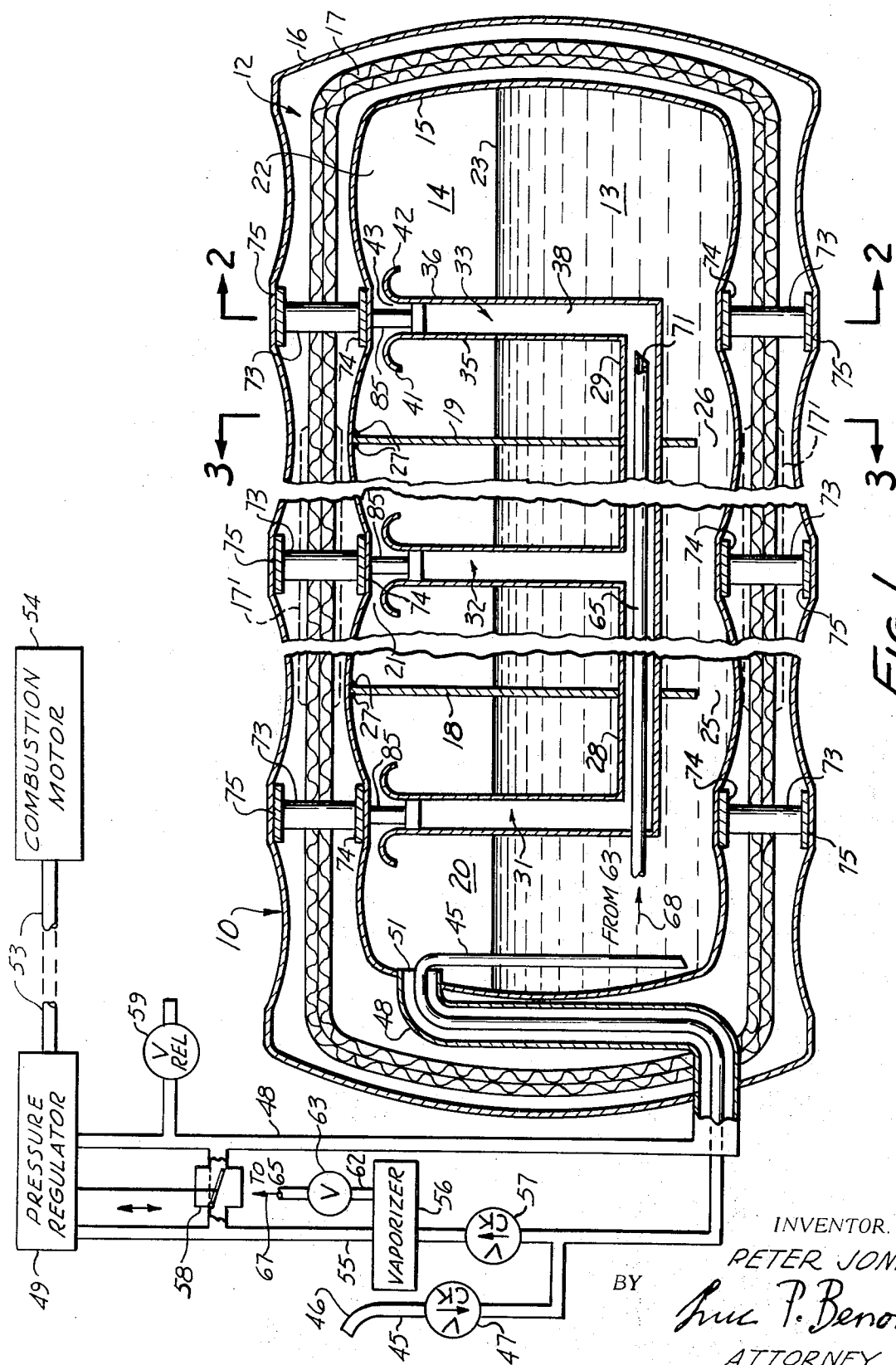
Attorney—John E. Wagner

[57] **ABSTRACT**

A container for liquefied gas has at least two separate compartments for containing the gaseous phase. Gas ducts are provided for conducting gas of the gaseous phase between the compartments in heat-exchange relationship with the liquefied gas.

39 Claims, 5 Drawing Figures





INVENTOR.
PETER JONES
BY
Rue P. Benoit
ATTORNEY.

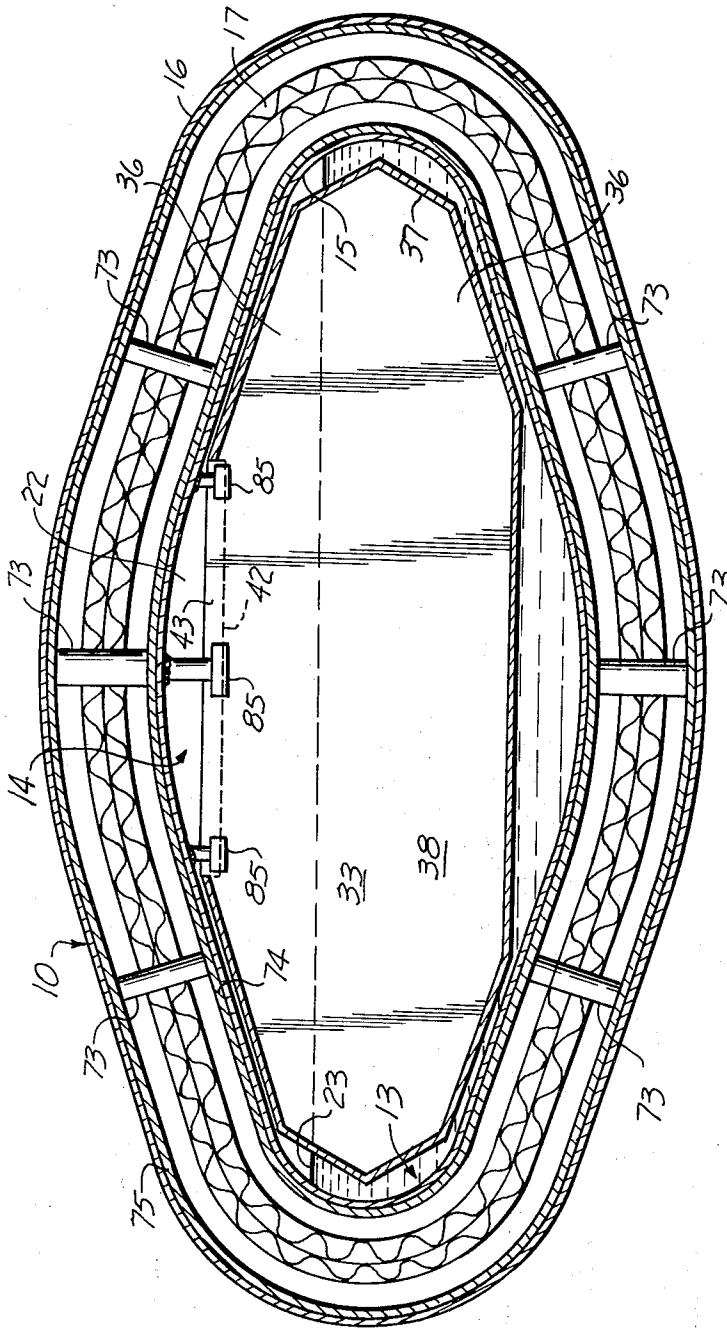


FIG. 2

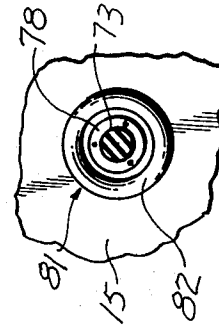


FIG. 5

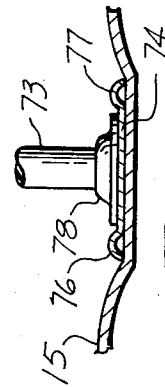


FIG. 4

LIQUEFIED GAS CONTAINERS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The subject invention relates to containers for liquefied gas.

2. Description of the Prior Art

The utility of liquefied gases is well known. By way of example, gases have in the past been liquefied for storage, transportation and/or refrigeration purposes. Any gas is liquefiable. Representative examples of gases which have in the past been liquefied on a large scale include oxygen, nitrogen, helium, argon, gaseous hydrocarbons, or mixtures thereof, such as those known as natural gas. The utility of these and other gases is well known. Natural gas or other gaseous hydrocarbons may, for instance, be employed as fuel in heat generation or vehicle propulsion. Oxygen may be employed for breathing purposes at high altitudes or for augmented combustion. Helium may be employed in lighter-than-air craft or gas mixtures for deep sea diving.

In the storage or transportation of liquefied gases, a gaseous phase occurs or exists above the liquid phase. In practice this gaseous phase develops a high pressure, particularly in periods of time when none or only a small portion of the gas developed from the liquid phase is drawn from the gas container.

Probably the oldest remedy against this gas pressure buildup, which eventually would destroy the gas container, has been to exhaust gas from the container from time to time into the atmosphere, such as by means of a pressure relief valve. This procedure is very uneconomical in that it wastes large amounts of the stored gases. This procedure also tends to contaminate the environment. Violent explosions have been reported as a result of this procedure in the case of combustible or combustion-sustaining gases.

A typical example of a prior art attack of the problem is apparent from the U.S. Pat. No. 2,260,357, by G.H. Zenner, issued Oct. 28, 1941. According to Zenner, measures are taken which increase the length of requisite liquid-removing and liquid-heating pipes between a liquefied gas level inside the container, and the pipe outlet at the container top. In practice, the benefits derived from this prior-art construction are necessarily limited by the fact that the proposed increase in the pipe length is, of course, limited by the size of the vessel. Another prior-art line of attack of the problem is, for instance, apparent from the U.S. Pat. No. 3,030,780, by P. E. Loveday, issued Apr. 24, 1962. This type of proposal relies for its effectiveness on the use of a special refrigerant for cooling the liquid and gaseous phases of the stored gas. The necessity of a special refrigerant renders the operation of the liquefied gas container cumbersome and expensive and takes away considerable space inside the container that could otherwise have been used for gas storage purposes.

In a somewhat different though related vein, prior-art thermally insulating containers for liquid gas storage or transportation, or for insulated receptacles and the like, suffer from an excessive loss of heat through the container walls. This is particularly true if the walls have to be supported relative to each other for structural or other reasons.

SUMMARY OF THE INVENTION

The subject invention overcomes or materially alleviates these disadvantages.

It is broadly an object of the subject invention to provide containers for liquefied gases and gaseous phases thereof.

It is a more specific object of the invention to provide containers for liquefied gases in which the pressure of the gaseous phase is automatically kept within manageable proportions without an excessive venting of gas to the environment.

It is a further object of the invention to provide containers for liquefied gases that may be employed as vehicle fuel tanks.

It is a more specific object of the invention to provide vehicle fuel tanks of this type which may be mounted at the outside of vehicles, such as at the bottom thereof below the trunk or other space.

It is a further object of the invention to provide fuel tanks of this type, or other liquefied gas containers, which conserve the stored gas by materially reducing the necessity of gas venting to the environment.

It is a further object of the subject invention to provide thermally insulating containers which have spacers between an inner receptacle and an outer shell and which are characterized by materially reduced heat conduction by way of the spacers.

It is a related object of the invention to provide thermally insulating containers of greatly increased structural strength and yet materially reduced thermal losses.

From one aspect thereof, the subject invention resides in a container for liquefied gas and a gaseous phase thereof, comprising in combination, thermally insulated means for enclosing a supply of the liquefied gas and the gaseous phase, means inside the enclosing means for providing at least two separate compartments for containing the gaseous phase, and means inside the enclosing means for conducting gas of the gaseous phase between the compartments in heat-exchange relationship with the liquefied gas.

In accordance with a preferred embodiment of the subject invention, the gas conducting means include gas duct means which are immersed in the supply of liquefied gas. The great advantages realized by a practice of the subject invention are explained in great detail in the further course of this disclosure. At the present juncture, it should be understood that the expression "gas" as herein employed is intended to cover at least the above mentioned gases or gas mixtures.

From another aspect thereof, the invention resides in a thermally insulating container comprising, in combination, a receptacle, an outer shell spaced from the receptacle, thermal insulation between the receptacle and the outer shell, spacers of thermally insulating material extending between the receptacle and the shell, substantially each of these spacers having a first height and first lateral dimensions, first base members of structurally rigid material attached to the receptacle for receiving the spacers, substantially each of these first base members having a height several times smaller than the mentioned first height and lateral dimensions larger than the mentioned first lateral dimensions, and second base members of structurally rigid material attached to the shell for receiving the spacers, substantially each of these second base members hav-

ing a height several times smaller than the mentioned first height and lateral dimensions larger than the mentioned first lateral dimensions.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention and its various aspects will become more readily apparent from the following detailed description of preferred embodiments thereof illustrated by way of example in the accompanying drawings, in which:

FIG. 1 is a longitudinal section of a liquid gas fuel tank in accordance with a preferred embodiment of the subject invention, and includes a diagrammatic showing of associated parts;

FIG. 2 is a transverse section view taken along line 2 — 2 of FIG. 1;

FIG. 3 is a transverse section view taken along line 3 — 3 of FIG. 1;

FIG. 4 illustrates, on an enlarged scale, and partially in section, a detail of preferred construction of the container of FIGS. 1, 2 and 3, in accordance with a preferred embodiment of the subject invention; and

FIG. 5 is a fractional top view, on an enlarged scale, of a modification of the construction of FIG. 4, in accordance with yet another preferred embodiment of the subject invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

The best mode presently contemplated of carrying out the subject invention is embodied in a liquid-gas fuel tank, since the availability of such gas-saving tanks for minimum-pollution vehicles will solve one of the most pressing needs presently confronting man's ecology. It should, however, be understood that no limitation of the utility of the invention is thereby intended, inasmuch as the principles of the subject invention can be applied to the solution of various types of liquefied gas storage or transportation problems, as those skilled in this art will readily perceive from this disclosure.

The container 10 of FIGS. 1 to 3 has thermally insulated means 12 for enclosing a supply of liquefied gas 13 and a gaseous phase 14 thereof. The enclosing means 12 include an elongate sealed receptacle 15 for the liquefied 13 and gaseous phase 14, a shell 16 spaced from and enclosing the receptacle 15, and thermal insulation 17 between the receptacle 15 and the shell 16. Means for maintaining the shell and the receptacle spaced from each other will be described in the further course of this disclosure.

Spaced solid baffles 18 and 19 are located inside the receptacle 15 to provide separate compartments for containing the gaseous phase. In practice, at least one baffle 18 or 19 is required for providing at least two separate compartments for containing the gaseous phase. In FIG. 1, two baffles 18 and 19 are shown for providing three compartments 20, 21 and 22 for containing the gaseous phase 14.

In the practice of the subject invention, it is important that the baffles 18 and 19 isolate the compartments 20, 21 and 22 from each other and do not permit gas leakage from one compartment to another by way of any part of the space above the level 23 of the liquid gas supply 13 in the container or tank 10. Three measures are taken in the preferred embodiment of FIGS. 1 to 3 to assure this result. First, the baffles 18 and 19 are of an impervious cold-resistant material. Preferably, this material has a relatively low heat conductivity.

Suitable materials include stainless steel or other nickel-steel alloys containing nine or more percent by weight of nickel, or fiberglass-reinforced epoxy or polyurethane-based plastics.

Secondly, the baffles 18 and 19 extend throughout the cross section of the receptacle 15, leaving only small spaces 25 and 26 at the bottom thereof for the passage of liquefied gas along the container 10. Thirdly, each baffle 18 and 19 is securely joined to the inner wall of the receptacle 15 by means of continuous welds or other gas-impervious seams 27.

The reason for the gas flow isolation provided by the baffles 18 and 19 is to force gas to flow only between the compartments in heat-exchange relationship with the liquefied gas 13. This intercompartmental flow of gas proceeds in the preferred illustrated embodiment by way of gas ducts 28 and 29 which are immersed in the supply of liquefied gas 13 and which extend through the baffles 18 and 19, respectively. The ducts 28 and 29 are in practice located sufficiently close to the bottom of the receptacle 15 to assure their continued immersion in the liquefied gas supply 13 during virtually the entire useful operation of the container or tank 10 from one liquid gas filling to the next.

Three hollow baffles 31, 32, and 33 are provided in the illustrated preferred embodiment to conduct gas to and from the immersed ducts 28 and 29, and to and from the gas compartments 20, 21, and 22, respectively. The structure and design of the baffles 31 to 33 will be explained with the aid of the baffle 33.

Each hollow baffle 31 to 33 has a pair of spaced baffle plates 35 and 36 and a sealed peripheral flange or side and bottom 37 (see FIG. 2) for delimiting a hollow space or cavity 38 which is not filled by the liquid gas 13. Each baffle plate of the hollow baffles 31 to 33 extends through the liquid and gaseous phases from the vicinity of the bottom of the receptacle 15 to the top of the receptacle 15. The baffle plates and peripheral flange are preferably of a material having high heat conductivity. By way of example, suitable materials include aluminum, copper or brass. The ducts 28 and 29 may be of the same material as the hollow baffles 31 to 33.

The receptacle 15 may, for example, be of aluminum, stainless steel or other nickel-steel alloy containing nine percent or more by weight of nickel, or a fiberglass-reinforced epoxy or polyurethane-based plastic. The outer shell 16 may be of one of these materials or alternatively of carbon steel or reinforced polyester plastic.

The hollow spaces inside the baffles 31 to 33 are interconnected by the immersed ducts 28 and 29 as shown. In addition, parts of the baffles 31 to 33 are themselves immersed in the liquefied gas supply 13 as shown.

If the container 10 is used as a vehicle tank or is employed in another situation in which splashing of the liquid gas inside the receptacle 15 is likely, it is advantageous to provide each plate 35 and 36 of the hollow baffles 31 to 33 with a splash guard 41 and 42, respectively. As apparent from FIGS. 1 and 2, these splash guards are in the form of bent lips which are located at the top opening 43 of each hollow baffle and which act somewhat in the manner of a plowshare in turning about liquefied gas splashing against the hollow baffles during the operation of the container or tank 10. In this manner, the lips 41 and 42 at each hollow baffle im-

pede entry of liquefied gas into these baffles and into the ducts 28 and 29.

The liquefied gas 13 is introduced into the receptacle through a fill-line 45 that extends from an inlet nozzle 46 to the vicinity of the bottom of the receptacle 15, and that includes a check valve 47 for preventing return of liquefied gas or of a gaseous phase to the fill nozzle 46. Part of the liquefied gas fill-line extends through a vapor line 48 which leads from the gas space 14 in the receptacle 15 to a pressure regulator 49. In practice, the inlet 51 of the vapor line 48 is located closely adjacent the top of the receptacle 15 so that no liquefied gas will enter the vapor line. If desired, a splash guard (not shown) similar to the members 41 and 42 may be associated with the vapor line inlet 51 to prevent entry of liquefied gas into the vapor line 48.

Operation of the container or tank 10 proceeds in a conventional manner as far as the removal of gas from the container or tank is concerned. Accordingly, the pressure regulator 49 is of a conventional type which senses the pressure in the gas space 14 and which permits gas to flow from the chamber 20 through the vapor line 48 and into a gas line 53 as long as the gas pressure above the liquid level 23 has a relatively high value. In accordance with standard practice, the gas flowing through the line 53 may be employed as a fuel of an internal combustion engine or motor 54. Natural gas or other hydrocarbon gases, contained in liquefied gas tanks, have been used for years to drive automotive combustion engines. Despite of their high ecological and environmental value, such drives have, however, been severely handicapped by the above mentioned inadequacy of prior-art liquid gas fuel tanks or containers. Upon completion of the present description of the gas removal equipment, this disclosure will proceed in explaining in detail the manner in which the subject invention overcomes this severe prior-art handicap and provides the means for a widespread utilization of clean vehicle propulsion systems that are characterized by low emission and yet modest operating cost.

When the pressure in the gas space 14 of compartment 20 drops to a median level, the pressure regulator 49 disconnects the gas line 53 from the vapor line 48 and connects this gas line 53 to a vaporizer line 55. As its name implies, the vaporizer line 55 is connected to the outlet of a vaporizer 56 which may also be of a conventional type.

The vaporizer 56 receives liquefied gas from the supply 13 inside the receptacle 15 through the liquefied gas line 45 and through a check valve 57 which prevents vapor from backing into the line 45. The vaporizer 56 vaporizes the liquefied gas received from the container 10 and the pressure regulator 49 applies this vaporized gas from the line 55 to the gas line 53 and from there to the motor 54 where it is used as a fuel.

If the pressure in the gas space 14 or compartment 20 drops to a low value, the pressure regulator opens a conventional pressurizer valve 58 between the lines 48 and 55. In this manner, vaporized gas provided by the vaporizer 56 is applied by way of the line 55, valve 58 and vapor line 48 to the gas space 14 or compartment 20 where it will exert a pressure on the liquid level 23. As a result of this exerted pressure, liquefied gas will be forced through the line 45 and check valve 57 into the vaporizer 56 where it will be vaporized and forwarded through the line 55 with the result that an adequate gas

pressure in the line 53 and at the combustion motor 54 is maintained.

In practice, the gas pressure inside the container 10 can be maintained below a dangerous value if the consumption of gas from the container 10 is continuous. In an automotive setting, this is typically the case if the vehicle is continuously driven at higher speed with only few intervening stops.

Problems are, however, encountered if the vehicle moves at relatively slow speed, such as in city traffic, and is compelled to stop frequently at traffic lights or temporary congestions. In this case, the gas pressure inside the container or tank 10 will rise rapidly and to excessively high values. The problem is further aggravated by the fact that vehicles have to be parked or left standing in a location for a longer period of time during which pressure buildup is apt to occur.

The main factor responsible for a gas pressure buildup is environmental temperature which causes heat to penetrate the insulation 17 and to enter the liquefied gas supply 13 and the gaseous phase 14. Since the latent heat of the liquefied gas 13 is many times higher than the specific heat of the gaseous phase 14, it follows that the gaseous phase will be heated to much higher temperatures than the liquid phase by environmental temperature influences.

Due to the resulting thermal expansion, the gas pressure inside the container or tank 10 will rise to high values which, if unchecked, would cause a bursting of the container or tank 10. In consequence, prior-art systems required containers or tanks that were of an impractical heavy construction and relied excessively on a frequent actuation of a pressure relief valve 59 connected to the gas space, such as by way of the vapor line 48.

The subject invention in accordance with the preferred embodiments thereof solves these problems with means that do not require any expensive and cumbersome pumps or other impractical driven parts inside the container or tank 10.

The chief feature of the subject invention in this respect is that the inside of the container or tank is compartmentalized and that gas can only flow from one compartment to another in intimate heat-exchange relationship with the liquefied gas 13.

By way of example, we may first consider the case in which the gas pressure in the container or tank 10 becomes excessive because only small amounts of gas are withdrawn through the vapor line 48 (slow traffic, frequent stops, low-level operation, etc.). In that case, the pressure in the compartment 20 will still be lower than the pressure in the compartment 21 and 22, because of the gas that is removed from the compartment 20. Accordingly, gas will flow from the compartment 22 to the compartment 21 and from there to the compartment 20. Because of the presence of the sealed baffles 18 and 19, no gas can flow above the liquid level 23. However, because of the presence of the hollow baffles 31 to 33 and the ducts 28 and 29, gas will flow from the compartment 21 through the hollow baffle space 38, duct 29, duct 28, and hollow baffle 31 to the compartment 20. Similarly, gas will flow from the compartment 21 through the hollow baffle 32, duct 28, and hollow baffle 31 to the compartment 20. This flow of gas will be in intimate heat-exchange relationship with the liquefied gas 13, since the ducts 28 and 29 are fully immersed, and the baffles 31 to 33 are partially immersed in the liquefied gas supply 13. Accordingly, gas flowing

from the compartments 21 and 22 to the compartment 20 will be chilled or cooled by the liquefied gas supply 13. This effect may be enhanced by making the baffle plates 35 and 36 of all hollow baffles and the ducts 28 and 29 of a heat-conductive material, such as aluminum, copper or brass. Because of the low temperature of the liquefied gas, the ducts 28 and 29 and hollow baffles 31 to 33 are capable of performing their function even if they are made of a material of relatively moderate heat conductivity, such as stainless steel.

If the container 10 is a vehicle fuel tank, gas will also be forced through the hollow baffles 31 to 33 and ducts 28 and 29 by motion imposed on the liquefied gas supply 13 during vehicle movements. For instance, if the vehicle takes a turn the liquid levels in the different compartments 20 to 22 will rise and fall unequally, thereby forcing gas through the baffles and immersed ducts. In all these cases, a gas will be chilled through its heat-exchange relationship with the liquefied gas 13 in the lower portions of the hollow baffles and in the immersed ducts 28 and 29. As a result, the gas pressure in the container or tank 10 will decrease as the gas contracts during cooling or chilling. Of course, the mentioned heat-exchange relationship will cause some heat to enter the liquefied gas supply 13. However, because of the high latent heat of the liquefied gas, only a relatively small amount of liquefied gas will be evaporated by the gas flowing through the hollow baffles and immersed ducts. In terms of overall result, the effect of the cooling of the gas will materially exceed the effect of liquefied gas evaporation due to that cooling.

Special considerations apply if the tank is in a stationary condition, such as during parking of the vehicle. In that case, there is no motion of the liquid level 23 or continual gas drainage from the receptacle 15 which would flush gas through the hollow baffles and immersed ducts. Yet the gas pressure in the container or tank tends to rise fairly steadily and, during prolonged parking or other stationary condition, reaches high values which necessitate frequent actuation of the pressure relief valve 59. This not only contaminates the environment, but in the case of combustible gases, raises a serious danger of explosion. This situation is particularly severe if the vehicle is parked in a garage or other confined structure.

According to another aspect of the subject invention, heat energy which inevitably enters the container and tank from the outside is employed to maintain the internal gas pressure within a range that permits a relatively light construction of the receptacle 15 and which reduces actuation of the relief valve 59 to a minimum.

By way of example and not by way of limitation, different embodiments of the subject invention employ one or more of the following measures to achieve the latter goals: One of the gas compartments is larger than another gas compartment or other gas compartments and/or more thermal insulation is provided for one gas compartment than for another gas compartment or other gas compartments and/or the container includes means for providing a lower thermal input for one gas compartment than for another gas compartment or other gas compartments and/or the container includes means for providing in one gas compartment a higher mass weight of the gaseous phase than in another gas compartment or other gas compartments.

Specific implementations of these preferred embodiments will now be explained with the aid of FIG. 1.

In FIG. 1 two breaks through the container or tank 10 are shown between the baffles 18 and 19. This is intended to indicate that the central gas compartment 21 is larger than the extreme gas compartments 20 and 22. Even though the central compartment 21 is larger than the compartments 20 and 22, the longitudinal dimension of the central compartment 21 is kept below a value at which the total wall area around the central chamber 21 through which heat enters that chamber would be larger than, or equal to, the total wall area through which heat enters the chamber 20 or the total wall area through which heat enters the chamber 22. In fact, the total wall area through which heat enters the chamber 21 is in a preferred embodiment of the invention considerably smaller than the total wall area through which heat enters the chamber 20 or the total wall area through which heat enters the chamber 22. This is easily accomplished in practice since the wall area through which heat enters the chamber 20 or the chamber 22 includes not only the wall sections of the receptacle 15 that circumferentially surround the compartment 20 or the compartment 21, but also the vertical section of the receptacle 15 which laterally delimits the compartment 20, or the other vertical section of the receptacle 15 which laterally delimits the compartment 22. It is thus readily possible to make the central chamber larger than the extreme chambers and yet keep the heat input to the central chamber smaller than the heat input to the extreme chambers. Moreover, and as indicated at 17', the heat insulation for the central chamber 21 may be made heavier than the heat insulation 17 for the chambers 20 and 22, so that the heat input to the chamber 21 is correspondingly reduced relative to the heat input to the chambers 20 and 22.

If environmental heat enters the container or tank 10, the gas phase in the compartments 20 and 22 will expand faster than the gas phase in the compartment 21, since the heat input into the compartments 20 and 22 is larger than the heat input into the compartment 21. In consequence, gas will flow through the hollow baffle 31, immersed duct 28, and hollow baffle 32 from the compartment 20 into the central compartment 21. At the same time, gas will flow by way of the hollow baffle 33, the immersed duct 29, and the hollow baffle 32 from the compartment 22 into the central compartment 21. The intimate heat-exchange relationship between gases flowing in the hollow baffles and immersed ducts with the liquefied gas supply 13 cools these flowing gases considerably. This will cause these gases to contract in the hollow baffles and ducts, thereby causing more gas to be drawn into the baffle and duct structure. As a result, the pressure in the compartments 20 and 22 will be reduced considerably.

In the meantime, the heat which penetrates the insulation 17' will start to have its effect on the gas in the central compartment 21. Since that compartment is larger than the other compartments, the mass weight of the gas in the compartment 21 is larger than the mass weight of the gas in the compartment 20 or in the compartment 22. Since gas flows to the compartment 21 and is cooled in the process as just described, the mass weight of the gas in the central compartment 21 will increase further. The heat which slowly enters the compartment 21 will act on this increased mass rate and will expand the gas from the compartment 21 into the compartments 20 and 22 by way of the cooling baffles 31 to 33 and cooling ducts 28 and 29. This will again

cool the flowing gas thereby maintaining the gas pressure within reasonable limits. The processes just described will cycle back and forth until a gas mass weight balance is reached in the three compartments 20, 21, and 22. Renewed or further heat input into the container or tank 10 will renew the cycle. Again, the amount of liquefied gas 13 that is vaporized by gases flowing through the ducts 28 and 29 and baffles 31 to 33 does not produce an objectionable gas pressure increase, since the heat of vaporization of the liquefied gas 13 is hundreds of times higher than the specific heat of the gas phase.

To obtain the proper balancing effect, the provision of at least three gas compartments 20, 21, and 22 is preferred in the practice of the subject invention. However, the principles of the invention are also operable with only two compartments, provided that one of the compartments has the qualities ascribed above to the compartment 21 relative to the other of the two compartments.

Despite the provision of these splash guards 41 and 42, liquefied gas can sometimes enter or otherwise occur in the ducts 28 and 29 during the operation of the tank 10. To eliminate this liquefied gas and assure the continued operation of the hollow baffle and duct system, vaporized gas is derived from the vaporizer 56 by a conduit 62. The conduit 62 is normally closed by a valve 63. When the pressure in the tank suddenly arises because of clogging of the ducts 28 and 29 by accumulated liquid gas, the valve 63 is manually or, if desired, automatically opened to apply vaporized gas to a pipe 65 which is connected to the valve 63 as indicated by the arrows 67 and 68. The pipe 65 extends through the receptacle 15, outer shell 16, and insulation 17 in a conventional manner (not shown). The pipe 65 further extends through the ducts 28 and 29 as shown and terminates with an opening 71 adjacent the hollow space 38 in the baffle 33.

The heat of the vaporized gas flowing through the pipe 65 and exiting therefrom through the pipe opening 71 will vaporize any liquid gas accumulated in the ducts 28 and 29. The pressure increase caused by this vaporization is insignificant as only a small amount of liquid gas can accumulate in the ducts, and since the valve 63 is opened only for a very short period of time.

It will be appreciated that the principles of the subject invention so far disclosed are not limited in their applicability and operation to any particular shape or mode of insulation or support of the container or tank 10. However, since the principles of the subject invention maintain the pressure inside the container 10 at reasonable values, it is possible to design the container with a shape that permits the container or tank to be mounted outside the vehicle, such as at the bottom thereof below the trunk space. This further reduces the explosion hazard relative to tanks that are mounted inside the vehicle, such as in the normally closed vehicle trunk.

In accordance with this principle, the illustrated preferred embodiment of the container 10 has a substantially oval cross section (see FIGS. 2 and 3) both with respect to the receptacle 15 and with respect to the outer shell 16.

The thermal insulation 17 is located in the space between the receptacle 15 and shell 16. The insulation 17 preferably includes multilayer reflective sheet insulation of the type in my previous U.S. Pat. No. 3,397,720,

issued Aug. 20, 1968 and herewith incorporated by reference herein.

A plurality of pegs 73 of insulating material support the inner receptacle 15 with respect to the outer shell 16 and preserve the spacing therebetween. The pegs 73 extend through apertures in the insulation 17 in a tight fit which prevents the flow of gas along the pegs 73.

As seen in FIGS. 1 to 3, several mutually spaced bands or hoops 74 encompass and are attached to the inner receptacle 15. Similarly, several mutually spaced corresponding bands or hoops 75 encompass and are spaced from the inner receptacle 15 and are attached to the inside of the outer shell 16.

The hoops 74 and 75 are of structurally rigid material, such as metal. By contrast, the spacers 73 are of a thermally insulating material which is typically less rigid than the material of the hoops 74 and 75. Suitable materials for the pegs 73 include laminated polyester and fiberglass, laminated epoxy and fiberglass and laminated polyurethane and fiberglass. In practice, paper may be substituted for fiberglass in the mentioned laminates. Fiberglass is, however, preferred.

As shown by way of example in FIG. 4, the hoops 74 have rigidizing indentations 76 and 77 along the sides thereof. Similar indentations may be provided along the sides of the outer hoops 75.

One circular member 78 for each end of a peg 73 is welded to the hoop 74 or the hoop 75 by such means as spot welding. A representative configuration of the circular member 78 is apparent from FIGS. 4 and 5. It has a central aperture for receiving an end of the corresponding peg 73.

As best seen in FIG. 1, circumferential portions of the inner receptacle 15 are indented outwardly between and adjacent the hoops 74. Corresponding portions of the outer shell 16 are indented inwardly between and adjacent the hoops 75. The rigidizing effect of these indentations cooperate with the increased lateral dimensions of the hoop 74 and 75 relative to the smaller lateral dimensions or diameter of the pegs 73. The result of this cooperation is a greatly increased strength which permits a substantial reduction of the required number of spacers or pegs 73 relative to the requisite number of spacers in prior-art structures that did not have these inventive features. (See for instance U.S. Pat. No. 2,000,882, by D.F. Comstock, issued May 7, 1935 and Reissued Patent 21,618, by W.C. O'Leary, issued Nov. 5, 1940, and herewith incorporated by reference herein).

Also, the fact that the structurally more rigid hoops 74 and 75 have a much smaller height than the pegs 73 increases the available heat insulation provided by the pegs, since they are of smaller cross section than the hoops.

The better insulation provided by the pegs 73 and the reduction in number of these pegs greatly decreases the environmental heat input to the inside of the receptacle 15. In this manner, the danger of objectionable pressure increases inside the vessel is further reduced.

The hoops 74 and 75 may be viewed as bare members for the pegs 73. Accordingly, the hoops may be replaced by circular members 81 which have an indented ridge 82 that corresponds to the ridge 76 or 77 shown in FIG. 4. By using circular base members 81 of a structurally more rigid material than the pegs 73, the principles of the currently discussed aspect of the subject invention are applicable to containers other than those

shown in FIGS. 1 to 3. For instance, these principles may be employed to the construction of insulated cabinets in general.

In FIGS. 1 and 2 the hollow baffles 31 to 33 are suspended by mounting members shown at 85. These may be of metal or of the same material as the pegs 73. The mounting members 85 are welded or otherwise fastened to the inner receptacle 15 on the one hand, and to the baffle plates of the hollow baffles 31 to 33 on the other hand. The hollow baffles 31 to 33 and ducts 28 and 29 are further supported by the baffles 18 and 19 through which the ducts 28 and 29 extend.

The receptacle 15 and outer shell 16 are of high-vacuum tight construction and the space between the receptacle 15 and outer shell 16 is evacuated to establish a high vacuum in that space in accordance with standard practice in cryogenic technology. To maintain the requisite high vacuum, a conventional getter material may be provided in the space between the receptacle 15 and the outer shell 16.

I claim:

1. A container for liquefied gas and a gaseous phase thereof, comprising in combination:
 - thermally insulated means for enclosing a supply of said liquefied gas and said gaseous phase;
 - means inside said enclosing means for providing at least two separate compartments including a first compartment and a second compartment each containing liquified gas and said gaseous phase; said first compartment having a larger volume and a smaller surface area per unit of volume exposed to heat transfer through said thermally insulated means than said second compartment; whereby the rate of thermal input to said first compartment from the exterior is less than that of the second compartment and
 - means inside said enclosing means for conducting gas of said gaseous phase between said compartments in heat-exchange relationship with said liquefied gas contained within said compartments.
2. A container as claimed in claim 1, including: means for providing a lower thermal input for the first of said compartments than for the other of said at least two separate compartments.
3. A container as claimed in claim 1, wherein: said compartment providing means include baffle means extending from one surface of the interior of said compartment extending throughout said gaseous phase and into said supply of liquefied gas, whereby the only communication path between said gaseous phase portions is through said liquid phase.
4. A container as claimed in claim 1, wherein: said liquefied gas is a vehicle fuel; and said container is a vehicle fuel tank.
5. A container as claimed in claim 1, wherein: said enclosing means include an elongate sealed receptacle for said liquefied gas and gaseous phase.
6. A container as claimed in claim 1, wherein: said receptacle has a substantially oval cross section.
7. A container as claimed in claim 1, wherein: said compartment-providing means include means for providing at least three of said separate compartments for containing liquid gas and said gaseous phase.
8. A container as claimed in claim 7, wherein:

the first of said compartments is located between the other of said at least three separate compartments, said first compartment being larger in volume than each of said other compartments and lesser surface area exposed to heat transfer through said thermally insulator means than at least one of said other compartments.

9. A container as claimed in claim 7, wherein: said thermally insulated means include means for providing more insulation for the first of said compartments than for the other of said at least two separate compartments.
10. A container as claimed in claim 1, wherein: said gas conducting means include hollow baffle means in each of said compartments, said hollow baffle means extending into said gaseous phase including openings communicating with said gaseous phase and into said liquefied gas supply for conducting said gaseous phase between said compartments in intimate heat-exchange relationship with said liquefied gas.
11. A container as claimed in claim 10, wherein: said compartment providing means include between each two adjacent hollow baffle means a further baffle means extending throughout said gaseous phase and into said supply of liquefied gas.
12. A container as claimed in claim 11, wherein: said enclosing means include an elongate sealed receptacle for said liquefied gas and gaseous phase; and said hollow baffle means and said further baffle means extend substantially transversely of said elongate receptacle.
13. A container as claimed in claim 12, wherein: said elongate receptacle and said further baffle means have substantially oval cross sections.
14. A container as claimed in claim 13, wherein: said hollow baffle means include baffle sheets having substantially oval cross sections.
15. A container as claimed in claim 1, wherein: said enclosing means include an elongate sealed receptacle for said liquefied gas and gaseous phase, a shell spaced from and enclosing said receptacle, means for maintaining said shell and said receptacle spaced from each other, and thermal insulation between said receptacle and said shell.
16. A container as claimed in claim 15, wherein: said thermal insulation includes multilayer reflective sheet insulation.
17. A container as claimed in claim 15, wherein: said means for maintaining said shell and receptacle spaced include spacers of thermally insulating material extending between said receptacle and said shell, substantially each of said spacers having a first height and first lateral dimensions, first base members of structurally rigid material attached to said receptacle for receiving said spacers, substantially each of said first base members having a height several times smaller than said first height and lateral dimensions larger than said first lateral dimensions, and second base members of structurally rigid material attached to said shell for receiving said spacers, substantially each of said second base members having a height several times smaller than said first height and lateral dimensions larger than said first lateral dimensions.

18. A container for liquefied gas and a gaseous phase thereof comprising in combination;
 thermally insulated means for enclosing a supply of said liquefied gas and said gaseous phase;
 means inside said enclosing means for providing at least two separate compartments including a first compartment and a second compartment each containing liquified gas and said gaseous phase;
 said first compartment having a larger volume and a smaller surface area exposed to heat transfer through said thermally insulated means than said second compartment; and
 means inside said enclosing means for conducting gas of said gaseous phase between said compartments in heat-exchange relationship with said liquefied gas contained within said compartments
 wherein said compartment providing means includes means for providing at least three of said separate compartments for containing liquid gas and said gaseous phase and wherein
 said thermally insulated means includes means for providing more insulation for said larger first compartment than for said other compartments.

19. A container for liquefied gas and a gaseous phase thereof, comprising in combination:
 thermally insulated means for enclosing a supply of said liquefied gas and said gaseous phase;
 means inside said enclosing means for providing at least two separate compartments including a first compartment and a second compartment each containing liquefied gas and said gaseous phase;
 said first compartment having a larger volume and a smaller surface area per unit of volume exposed to heat transfer through said thermally insulated means than said second compartment; and
 means inside said enclosing means for conducting gas of said gaseous phase between said compartments in heat-exchange relationship with said liquefied gas contained within said compartments;
 wherein said gas conducting means include gas duct means immersed in said supply of liquefied gas.

20. A container as claimed in claim 19 wherein:
 said gas phase conducting means extending into the gas phase region of each compartment and include means for impeding entry of liquefied gas into said gas conducting means.

21. A container as claimed in claim 19, including:
 means operatively associated with said gas conducting means for vaporizing liquefied gas occurring in said gas conducting means.

22. A container as claimed in claim 19, including:
 means extending into said gas duct means for vaporizing liquefied gas occurring in said gas conducting means.

23. A container for liquefied gas and a gaseous phase thereof, comprising in combination;
 thermally insulated means for enclosing a supply of said liquefied gas and said gaseous phase;
 means inside said enclosing means for providing at least two separate compartments including a first compartment and a second compartment each containing liquefied gas and said gaseous phase;
 said first compartment having a larger volume and a smaller surface area exposed to heat transfer through said thermally insulated means than said second compartment; and

means inside said enclosing means for conducting gas of said gaseous phase between said compartments in heat-exchange relationship with said liquefied gas contained within said compartments
 said compartment providing means including baffle means extending throughout said gaseous phase into said supply of liquefied gas;
 wherein said gas conducting means include gas duct means immersed in said supply of liquefied gas.

24. A container as claimed in claim 23, wherein:
 said conducting means include means for impeding entry of liquefied gas into said gas conducting means.

25. A container for liquefied gas and a gaseous phase thereof, comprising in combination:
 thermally insulated means for enclosing a supply of said liquefied gas and said gaseous phase;
 means inside said enclosing means for providing at least two separate compartments including a first compartment and a second compartment each containing liquefied gas and said gaseous phase;
 said first compartments having a larger volume and a smaller surface area per unit of volume exposed to heat transfer through said thermally insulated means than said second compartment;
 means inside said enclosing means for conducting gas of said gaseous phase between said compartments in heat-exchange relationship with said liquefied gas contained within said compartments;
 wherein said gas connected means includes hollow baffle means in each of said compartments;
 said hollow baffle means extending into said gaseous phase and into said liquified gas supply for conducting said gas in heat exchange relationship with said liquified gas;
 said gas conducting means further includes means for impeding entry of liquefied gas into said hollow baffle means.

26. A container as claimed in claim 25, wherein:
 said entry impeding means include means for turning about liquefied gas splashing against said hollow baffle means.

27. A container as claimed in claim 25, wherein:
 said gas conducting means further include gas duct means immersed in said supply of liquefied gas and extending between said hollow baffle means in communication with hollow spaces in said hollow baffle means.

28. A container for liquefied gas and a gaseous phase thereof, comprising in combination:
 thermally insulated means for enclosing a supply of said liquefied gas and said gaseous phase;
 means inside said enclosing means for providing at least two separate compartments for containing said gaseous phase; and
 means inside said enclosing means for conducting gas of said gaseous phase between said compartments in heat exchange relationship with said liquefied gas,
 wherein said enclosing means include an elongated sealed receptacle for said liquefied gas and gaseous phase,
 a shell spaced from and enclosing said receptacle,
 means for maintaining said shell and said receptacle spaced from each other, and
 thermal insulation between said receptacle and said shell,

wherein said means for maintaining said shell and receptacle spaced include a number of spaced first hoops of structurally rigid material encompassing and attached to said receptacle, a number of spaced second hoops of structurally rigid material encompassing and spaced from said receptacle and attached to said shell, and spacers of thermally insulating material extending between and engaging said first and second hoops.

29. A container as claimed in claim 28, wherein: said first and second hoops are of metal.

30. A container as claimed in claim 28, wherein: said receptacle is outwardly indented between said first hoops.

31. A container as claimed in claim 30, wherein: said shell is inwardly indented between said second hoops.

32. A thermally insulating container comprising in combination:

a receptacle;
an outer shell spaced from said receptacle;
thermal insulation between said receptacle and said outer shell;

spacers of thermally insulating material extending between said receptacle and said shell, substantially each of said spacers having a first height and first lateral dimensions;

first base members of structurally rigid material attached to said receptacle for receiving said spacers, substantially each of said first base members having a height several times smaller than said first height and lateral dimensions larger than said first lateral dimensions; and

second base members of structurally rigid material attached to said shell for receiving said spacers, substantially each of said second base members having a height several times smaller than said first height and lateral dimensions larger than said first lateral dimensions;

said first and second base members constituting portions of continuous hoops encircling said receptacles and shell respectively.

33. A container as claimed in claim 32, wherein: said receptacle includes outwardly positioned indentations between said first base members.

34. A container as claimed in claim 33, wherein: said shell includes outwardly extending preformed indentations between said second base members.

35. A system for storage of liquified gas comprising: an outer shell;

thermal insulation means within said shell;

a gas containing vessel within said shell thermally insulated from ambient conditions by said thermal insulation means;

conduit means for introducing gas into said vessel and for removing gas from said vessel to the exterior of said shell;

said vessel including at least two compartments, a first compartment and a second compartment;

said first compartment of said vessel having a larger fuel mass capacity and a lower thermal transfer capacity than said second compartment;

means conducting gaseous phase gas between said first and second compartments;

said gaseous phase conducting means traversing the major distance between said first and second compartment immersed in liquid phase gas;

said gaseous phase conducting means having high thermal conductivity whereby gaseous phase gas passing between said first and second compartments is in intimate thermal transfer relationship with liquid phase gas in said compartments.

36. The combination in accordance with claim 35 wherein said conduit means includes a plurality of baffles extending generally vertical in said vessel and extending into the region of gaseous and liquid phase gas contained in said vessel.

37. The combination in accordance with claim 35 wherein said conduit means communicates with said second compartment of said vessel whereby gas is introduced into and withdrawn from said vessel via said second compartment.

38. The combination in accordance with claim 35 wherein said second compartment of said vessel is elongated and encloses said first compartment on three sides whereby said second compartment is exposed to thermal transfer on substantially all outer sides and said first compartment is exposed to thermal transfer through said second compartment on three sides and exposed to thermal transfer outward from said vessel on substantially one side only.

39. The combination in accordance with claim 38 wherein said thermal insulation means is substantially uniform in insulation properties on each side of said vessel whereby the thermal transfer through said thermal insulation means from said first compartment is less than the total thermal transfer from said second compartment.

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