UNITED STATES PATENT OFFICE

LIQUEFIED GAS CONTAINER

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19 Claims. (Cl. 62—1)

1. This invention relates to improved containers for holding liquefied high vapor pressure gases, as for instance liquefied petroleum gases such as propane.

In the past, considerable difficulty has been encountered in the handling of propane and other liquefied gases by reason of the excessive thermal expansion of these materials upon increases in temperature. If a storage tank is filled completely with such a normally gaseous material in liquid form, the tendency for expansion of the liquid upon increase in temperature is often sufficient to rupture or explode the tank, or discharge its usually highly inflammable contents through a safety valve into the atmosphere. In order to prevent such rupture or indiscriminate popping of a safety valve, it is customary to only incompletely fill the tank with liquid, leaving an unfilled portion of the tank into which the liquid may expand upon an increase in temperature. However, this system relies completely on an operator to stop the filling process at a proper time, and has resulted in serious accidents where a careless or inexperienced operator has unintentionally overfilled a tank.

The general object of the present invention is to provide an improved type of liquefied gas container which is specially designed to automatically limit its filling at a condition in which a predetermined space remains unfilled with liquid. In this manner, I minimize the possibility of dangerous overfilling and avoid reliance on an operator's stopping the filling process at the proper time.

Structurally, I achieve such controlled filling by the employment of a container having two separate chambers, one of which is a main chamber into which the liquefied gas is filled, and the other of which is an auxiliary or "cage" chamber adapted to receive excess liquid from the main chamber upon thermal expansion of the liquid. In one form of the invention, the main and auxiliary chambers are contained within a common shell, in which case the two chambers may be separated at one side by a common wall. To permit gravity flow of the liquid back into the main chamber upon a subsequent fall of liquid level in the main chamber, the auxiliary chamber is desirably located above the main chamber. A preferred form of container comprises an upstanding desirably cylindrical tank having at its upper end a pair of vertically spaced walls, the upper one of which is upwardly convex and the lower of which is downwardly convex, to form between the walls a generally elliptical top auxiliary chamber.

Liquid flow from the main to the auxiliary chamber is controlled in part by a relief valve, adapted to prevent liquid flow into the auxiliary chamber under normal filling pressures, while opening to permit such flow in response to a predetermined increase in pressure resulting from an increase in temperature. This relief valve may be spring-loaded, and is desirably used in combination with a second relief valve discharging to the exterior of the two chambers. The second relief valve is loaded more heavily than the inter-chamber relief valve, so that upon increase in temperature, liquid first expands into the auxiliary chamber, and then if the temperature change is so drastic as to completely fill the auxiliary chamber, some liquid may be vented to the atmosphere.

After liquid has been expanded into the auxiliary chamber, it is desirable to provide means for conducting that liquid back into the main chamber upon a subsequent drop in pressure within the main chamber. For this reason, I may provide between the two chambers, and in addition to the inter-chamber relief valve, a second valve element adapted to permit such return flow from the auxiliary chamber to the main chamber. This second valve element may take the form of either a check valve permitting liquid flow from the auxiliary to the main chamber while closing off reverse flow, or a liquid level responsive valve adapted to permit liquid flow between the chambers when the main chamber is only partially filled, but to prevent such flow when the main chamber is substantially completely filled. When a liquid level responsive valve is employed, it serves the additional function of permitting vapor communication in either direction between the chambers when the main chamber is only partially filled, so that equal pressures are maintained in the two chambers, a feature which is particularly important where the two chambers are separated by a common wall. To assure most effective flow control, the second valve element may be constructed to function as both a check and level responsive valve, and for this purpose may take the form of a floatable ball check valve element.

Especially contemplated is an improved valve arrangement particularly adapted for use in the above discussed container system, and in which the relief and check and/or float valve functions are all performed by a single valve unit. For this purpose, one of the valve elements, i.e. either the relief or float-check valve element may contain a fluid passing opening, and the other valve element acts to control flow through that opening.
erably, the spring loaded inter-chamber relief valve element contains the opening, and a float type ball check valve permits fluid flow therethrough. As the liquid level in the main chamber reaches a height substantially filling that chamber, the ball is lifted upwardly against a seat to close off the opening through the relief valve and render it effective to prevent liquid flow into the auxiliary chamber. Such liquid flow is then permitted only when the pressure reaches a predetermined excessive value substantially greater than the filling pressure. When the liquid level in the main chamber then falls, the float valve falls to an open condition permitting return of liquid from the auxiliary to the main chamber.

The above and other features and objects of the present invention will be better understood from the following detailed description of the typical embodiments illustrated in the accompanying drawings, in which:

Fig. 1 is a side view, partly in section, of a first form of liquefied gas container embodying the invention;

Fig. 2 is an enlarged vertical section through the combined relief, float and check valve unit of the Fig. 1 device, the float valve element being shown in its open condition;

Fig. 3 is a sectional view corresponding to Fig. 2 but showing the float valve in its closed condition;

Fig. 4 is a view corresponding to Figs. 2 and 3, but showing the relief valve element in its open condition; and

Fig. 5 is a side partly sectional view of a modified form of container embodying the invention.

Describing first the form of the invention shown in Fig. 1 to 4, and with particular reference to Fig. 1, the upstanding liquefied gas container 10 there shown includes a vertically extending cylindrical side wall 11, an upwardly convex generally spherical top wall 12, and a downwardly convex bottom wall 18. The top and bottom walls 12 and 18 may be rigidly attached to the side wall in any suitable manner, as by annular welds 14 and 15. Bottom wall 18 may carry a depending circular ring 16 for supporting the container in the illustrated upstanding condition on a suitable supporting surface 17. Top wall 12 may carry an upwardly projecting cylindrical shield or guard 19 having an open upper end 19, for protecting the various later-to-be-described fittings and valves projecting from the upper side of the container.

Near its upper end, the shell formed by walls 11, 12 and 13 contains a downwardly convex generally spherical partition or inner wall 21, dividing the shell into a lower main chamber 22 into which liquefied gas may be filled, and an upper smaller auxiliary chamber 23 of generally elliptical vertical section for receiving excess liquid from chamber 22 upon thermal expansion thereof. Partition 21 may be secured to walls 11 and 12 by the same annular weld 14 which secures the top wall to the side wall. Upper chamber 23 should preferably have a volume equal to about 10 to 20 per cent of the total volume of both chambers. The shell walls 11, 12 and 13, and partition 21 may be formed of sheet metal, and are of course sufficiently strong to withstand without danger of rupture whatever pressure may be exerted by the contained liquefied gases. Typically, these walls and the partition may be formed to withstand pressures up to about 1250 p.s.i. g. where propane is being handled.

Connected into the top wall 12 of the container are a number of tubular fittings 24, 25, 26 and 27, which project downwardly to communicate with chambers 22 and 23 at a number of different locations. Of these various tubular fittings, number 24 projects downwardly to communicate with the upper portion of lower chamber 22, and carries at its upper end a conventional safety relief valve 28. This relief valve is of the usual construction, including a movable valve element 29 which acts in an opening direction by the fluid pressure within the tank, and a loading spring 30 adapted to resist opening movement of the valve element until the fluid pressure reaches a predetermined value. A second of the fittings or tubes 25 extends downwardly to a location near the bottom of lower chamber 22, to act as a liquid outlet tube, where it is desired to deliver the liquefied gas from the container in liquid form. Manually operated control valve 31 controls the discharge of such liquid from tube 25 to a line 32, leading to a piece of equipment using the liquefied gas.

Tubes 26, 27 and 28, which project downwardly into upper chamber 23, to indicate upon openings of valve 33 whether liquid has accumulated in that chamber. The fitting or tube 27, carrying control valve 34, communicates with the upper portion of main chamber 22 and may be used as either a filling fitting, or a vapor discharge fitting.

Fluid flow between chambers 22 and 23 is controlled by a combined relief, float and check valve unit 35, mounted at the central and lowermost portion of partition 21. Valve unit 35 may be removable from that location by threaded connection into a tubular mounting body 36, secured by annular weld 31 within a central opening in partition 21. Valve unit 35 is upwardly removable from within the container through a tubular access fitting 39 mounted within a central opening in the container top wall 12. This access fitting is normally closed by a suitable threaded plug 38.

Referring now to Figs. 2 to 4, valve unit 35 includes a tubular externally threaded body 40 communicating downwardly with lower chamber 22 and through lateral ports 41 with upper chamber 23. Body 40 contains a vertically movable circular relief valve element 42 slidably received within a cylindrical bore 43, and engagesate in a seat 44 in the upper chamber downwardly against transverse annular shoulder 45.

Relief valve element 42 is urged downwardly by a coil spring 46, which bears at its upper end against an adjusting element 45 threadedly engaging the valve body 40 at 47. Adjusting element 45 is retained in a desired position by an upper lock element 48, having a transverse groove 49 for engagement by a screw driver or other tool. As will be appreciated, during installation of valve unit 35 in the tank, the unit may be turned by means of a screw driver received in groove 49, to screw the valve unit into element 35. Relief valve element 42 contains a central opening 50, through which fluid may flow from chamber 22 upwardly for passage outwardly through ports 41 into chamber 25. About opening 50, relief valve element 42 forms an annular downwardly facing valve seat 51, against which a floatable ball check valve element 52 is upwardly engageable to close off communication between the two chambers.

In its upper position of Fig. 2, ball float 52 rests on a support element 53 threaded into the bottom of the tubular valve body 40, and containing circularly spaced apertures 54 through which fluid may by-pass ball 52. Ball 52 is of a material adapted to float on
the surface of the liquefied gas which the container is intended to hold, and may typically be a hollow air-filled ball having a thin metallic wall.

In placing the container of Fig. 1 in use, a filling line is connected to valve 34, to introduce a liquefied gas such as propane into main chamber 22 through tube 27. The liquefied gas is filled into the main chamber under a suitable predetermined filling pressure, typically about 200 pounds per square inch. At this point it is noted for clarity that where the term "filling pressure" is used in the present specification or claim, it refers to the pressure of the fluid within main chamber 22 during filling. During most of the time that the liquid is coming into chamber 22, float 52 is in its lower open position of Fig. 2, to permit free passage of vapor upwardly into chamber 23, and thus maintain substantially equal pressures above and beneath partition 21. The maintenance of such equal pressures in the two chambers minimizes the danger of rupturing partition 21 in normal use of the container.

As the liquid level within chamber 22 reaches the top of that chamber, float valve element 52 is lifted upwardly on the surge of the liquid to its Fig. 3 position of engagement with seat 51, to prevent the flow of any liquid upwardly through passage 50 and into upper chamber 23. At this point, an increase in the filling pressure will indicate to the operator that the main chamber 22 has been completely filled. However, the filling pressure of the liquid is not sufficient to force relief valve element 42 upwardly against the tendency of spring 45, and therefore the filling process is automatically stopped without passage of any liquid into chamber 22, even though the operator may neglect to close the filling valve immediately upon the completion of filling of chamber 22.

After chamber 22 has been filled, the filling line is disconnected from valve 34, and a vapor dispensing line may be connected to that valve, or the liquid dispensing line connected to valve 31, to deliver the contained material in either vapor or liquid form as desired. If the temperature of the liquid within chamber 22 increases to an extent causing an increase in the liquid pressure to a predetermined value substantially above the liquid filling pressure, as for instance to a pressure of about 250 pounds per square inch as against a filling pressure of about 200 pounds per square inch, relief valve element 42 and check valve element 52 are moved upwardly as a unit against the tendency of spring 45 to the open position of Fig. 4, in which excess liquid may flow upwardly within valve body 40 and outwardly through ports 41 into upper chamber 23, to relieve the excess pressure in the lower chamber.

As will be appreciated, the opening of relief valve element 42 is actually effected by the pressure differential between the main and auxiliary chambers, as developed after the closure of check valve element 52. Where the filling pressure is 200 pounds, and it is desired that valve element 42 open when the pressure within the main chamber reaches 250 pounds, that valve element may be set to open at a pressure differential of about 50 pounds. With such an arrangement, the pressure within both chambers is 200 pounds during filling, and until the ball check valve closes off communication therebetween, at which time the auxiliary chamber pressure ceases to change, and further increases in main chamber pressure set up in a pressure differential between the chambers, which differential pressure opens valve element 42 when it reaches 50 pounds.

The upper chamber is of a size to accommodate any liquid which may expand into it under temperatures which are expected to be encountered. However, should unforeseen conditions arise in which the upper chamber is completely filled with liquid and further expansion is still needed, safety valve 28 opens to discharge the necessary amount of the liquefied gas into the atmosphere. Valve 28 is set to open at a pressure well above the opening pressure of relief valve 42, 52, valve 28 typically opening at about 300 pounds per square inch.

After the passage of a sufficient amount of liquid upwardly from chamber 22 into chamber 23, relief valve element 42 moves downwardly under the influence of spring 45 to its closed position of Fig. 2. Upon a subsequent drop in the liquid level within chamber 22, either from thermal contraction or as a result of removal of some liquid from chamber 22, float 52 falls downwardly to its open condition of Fig. 2 to permit return gravity flow of the liquid from chamber 23 back into chamber 22. Such opening movement of float 52 also again places the two chambers in vapor communication, to maintain equal pressures above and beneath partition 21. As will be understood, during periods when the main chamber 22 is filled with liquid, and float valve element 52 is therefore elevated into engagement with seat 51, that element functions as a check valve member, which is closed against liquid flow into the auxiliary chamber while permitting liquid flow from the auxiliary chamber back into the main chamber.

Fig. 5 represents a variational form of the invention, including a horizontally elongated main tank 55 standing on legs 56, and an upper and smaller horizontally elongated auxiliary tank 57. At one end, main tank 55 has a number of fittings corresponding generally to the upper fittings of Fig. 1, and including a safety valve 58, a vapor outlet fitting 59, a filling fitting 60, a gauge fitting 61, and a liquid outlet fitting 62. These fittings may be protected by a suitable shield or guard 63.

Auxiliary tank 57 is mounted at the upper side of main tank 55 by a pair of vertically extending tubular elements 65, through which the two tanks are communicable at their opposite ends. Within tubular elements 65, removably mount a pair of combined relief, check and float valve units 56a of the type shown in Figs. 2 to 4. These units may be inserted into position through and removed from upper access openings 66, which are closed by plugs 67. A valve controlled liquid outlet fitting 68 may be provided within auxiliary tank 57 for indicating whether liquid is present in the auxiliary tank.

The operation of the Fig. 5 form of the invention is substantially the same as the Fig. 1 form, and will not be discussed in detail. Valves 35a in Fig. 5 operate in the same manner as valve 35 in Fig. 1, to prevent flow of liquid into the auxiliary tank under excessive temperature induced pressures. The provision of two valve units 56a at opposite ends of the tanks permits proper functioning of the apparatus even though the tanks may be inclined at an angle to the horizontal.

I claim:
1. Apparatus for containing liquefied gas com-
prising a first chamber into which liquefied gas may be filled, an auxiliary chamber communicable with said first chamber to receive excess liquid therefrom upon thermal expansion of the liquefied gas, and a relief valve closing off liquid flow from said first chamber to the auxiliary chamber under a predetermined normal filling pressure but operable to open and admit liquid to said auxiliary chamber in response to an increase in pressure within the first chamber to a predetermined value above said filling pressure, said apparatus including a valve unit operable to close said passage between said chambers and operable to pass said liquid from a direction from the auxiliary chamber back to the first chamber while closing off reverse liquid flow through said passage from the first chamber and into said auxiliary chamber.

4. Apparatus for containing liquefied gas comprising a first chamber into which liquefied gas may be filled, an auxiliary chamber communicable with said first chamber to receive excess liquid therefrom upon thermal expansion of the liquefied gas, a relief valve closing off liquid flow from said first chamber to the auxiliary chamber under a predetermined normal filling pressure but operable to open and admit liquid to said auxiliary chamber in response to an increase in pressure within the first chamber to a predetermined value above said filling pressure, said apparatus including a level sensor responsive to the level of liquid in said first chamber and a control responsive to a change in the level of liquid in said first chamber to control or actuate the valve unit in said auxiliary chamber.

5. Apparatus for containing liquefied gas comprising a first chamber into which liquefied gas may be filled, an auxiliary chamber communicable with said first chamber to receive excess liquid therefrom upon thermal expansion of the liquefied gas, a valve unit controlling fluid flow between said chambers, said valve unit including a relief valve element responsive to a change in pressure within the first chamber to a predetermined normal filling pressure but operable to open and admit liquid to said auxiliary chamber in response to a change in pressure within the first chamber to a predetermined value above said filling pressure, and said valve unit including a second valve element past which liquid may return from the auxiliary chamber back to said first chamber, one of said valve elements comprising a passage through which fluids may flow between said chambers, and the other valve element being relatively movable and operable to close said passage.

6. Apparatus for containing liquefied gas comprising a first chamber into which liquefied gas may be filled, an auxiliary chamber communicable with said first chamber to receive excess liquid therefrom upon thermal expansion of the liquefied gas, a valve unit controlling fluid flow between said chambers, said valve unit including a relief valve element movable between a first position for preventing liquid flow from said first chamber to the auxiliary chamber and a second position for permitting said flow, said relief valve element containing a passage through which fluids may flow between said chambers, a second valve element operable to close said passage and act to pass fluid therethrough from the auxiliary chamber back to said first chamber, and means for applying a force to prevent the movement of the valve element in a predetermined position.

7. Apparatus for containing liquefied gas comprising a first chamber into which liquefied gas may be filled, an auxiliary chamber communicable with said first chamber to receive excess liquid therefrom upon thermal expansion of the liquefied gas, a valve unit controlling fluid flow between said chambers, said valve unit including a relief valve element movable between a first position for preventing liquid flow from said first chamber to the auxiliary chamber and a second position for permitting said flow, said relief valve element containing a passage through which fluids may flow between said chambers, and means for applying a force to prevent the movement of the valve element in a predetermined position.

8. Mounting said valve unit at a first side of one
of the chambers and for removal into said one chamber, said one chamber having an access opening at a second side and opposite said valve unit through which the valve may be removed from said one chamber, and a closure for said access opening.

8. Apparatus for containing liquefied gas comprising a first chamber into which liquefied gas may be filled, an auxiliary chamber communicable with said first chamber to receive excess liquid therefrom upon thermal expansion of the liquefied gas, a valve unit controlling fluid flow between said chambers, said valve unit including a relief valve element responsive to a predetermined normal filling pressure but operable to open and admit liquid to said auxiliary chamber in response to an increase in pressure within the first chamber to a predetermined value above said filling pressure, and said valve unit having an access opening at its upper side opposite the valve unit for removal thereof, and a closure for said access opening.

9. Apparatus for containing liquefied gas comprising a first chamber into which liquefied gas may be filled, an auxiliary chamber positioned higher than said first chamber and communicable with said first chamber to receive excess liquid therefrom upon thermal expansion of the liquefied gas, and a relief valve closing off liquid flow from said first chamber to the auxiliary chamber under a predetermined normal filling pressure but operable to open and admit liquid to said auxiliary chamber in response to an increase in pressure within the first chamber to a predetermined value above said filling pressure, and said valve unit having an access opening at its upper side opposite the valve unit for removal thereof, and a closure for said access opening.

10. Apparatus for containing liquefied gas comprising a main chamber, fitting means for filling liquefied gas into and discharging it from said main chamber, a smaller auxiliary chamber mounted above said main chamber and communicable therewith, and a valve unit positioned at the upper side of said main chamber and at the lower side of said auxiliary chamber for controlling fluid flow between the chambers, said valve unit including a relief valve element movable between a first position for preventing liquid flow from said main chamber to the auxiliary chamber and a second position for permitting said flow, said relief valve element containing a passage through which fluids may flow between said chambers, a ball float valve element responsive to the gravitational force of said main chamber with liquid to close said passage, and a spring urging said relief valve element to closed position and of a strength to prevent opening movement of the relief valve element under a predetermined normal filling pressure but to allow said movement in response to a predetermined temperature induced increase in liquid pressure within the first chamber.

11. Apparatus for containing liquefied gas comprising a first chamber into which liquefied gas may be filled, an auxiliary chamber communicable with said first chamber to receive excess liquid therefrom upon thermal expansion of the liquefied gas, a relief valve closing off liquid flow from said first chamber to the auxiliary chamber under a predetermined normal filling pressure but operable to open and admit liquid to said auxiliary chamber in response to an increase in pressure within the first chamber to a predetermined value above said filling pressure, and a second relief valve discharging from said first chamber to the outside of both chambers and loaded to remain closed until the first chamber pressure reaches a value substantially higher than the opening pressure of said first relief valve.

12. Apparatus for containing liquefied gas comprising a horizontally elongated main tank, fluid filling and dispensing fitting means on said main tank, a horizontally elongated and smaller auxiliary tank mounted above said main tank and communicable therewith near opposite ends of the tanks, and a pair of valve units mounted at the upper side of said main tank at opposite ends thereof and controlling fluid flow between said tanks, each of said units comprising a relief valve element movable between a first position for preventing liquid flow from said first tank to the auxiliary tank and a second position for permitting said flow, said relief valve element containing a passage through which fluids may flow between said tanks, a ball float valve element responsive to substantial filling of said main tank with liquid to close said passage, and a spring urging said relief valve element to closed position and of a strength to prevent opening movement of the relief valve element under a predetermined normal filling pressure but to allow said movement in response to a predetermined increase in liquid pressure within the main tank.

13. Apparatus for containing liquefied gas as recited in claim 1, in which both of said chambers are formed within a common shell.

14. Apparatus for containing liquefied gas as recited in claim 1, in which both of said chambers are formed by an upstanding tubular shell having a bottom wall and an upwardly convex wall, and a downwardly convex partition extending across the shell beneath said top wall to form said first chamber therebeneath and said auxiliary chamber thereabove.

15. A valve unit for controlling fluid flow between a pair of upper and lower chambers, comprising a vertically extending tubular body externally threaded for removable connection into an internally threaded fitting between said chambers, a relief valve element in said body movable upwardly therein from a lower closed position to an upper open position in which liquid may pass upwardly between said chambers, a spring yieldingly urging said relief valve element downwardly toward closed position, and a float valve element floatable upwardly on a body of liquid to a position in which it closes off fluid flow upwardly between the chambers.

16. A valve unit as recited in claim 15, in which said tubular body has aperture means in its side
wall through which fluid flows between the interior of the body and the upper chamber, said relief valve element comprising a slide valve slidable in said body to open and close said aperture means and containing an opening, said float valve element being constructed and positioned to close said opening in the relief valve element by movement upwardly relative thereto.

17. A valve unit as recited in claim 16, in which said body has internal threads near its upper and lower ends above and beneath said aperture means, said valve unit including a plug element threaded into the upper end of said body and against which said spring bears upwardly, and a transverse apertured element threaded into the lower end of said body and against which said float valve element rests in a lower open position thereof.

18. A valve unit as recited in claim 16, including tool engaging means carried by said body and constructed to be engaged by a tool in a relation such that the tool may serve to turn the body and thereby screw it into said fitting.

19. A valve unit comprising a tubular vertically extending body containing a vertically extending cylindrical bore and having aperture means extending laterally through its side wall at the location of said bore, a slide valve element slidably engaging and movable vertically in said bore between a lower position in which said aperture means communicate with the interior of the body above said slide valve element and an upper position in which said aperture means communicate with the underside of said slide valve element, a spring urging said slide valve element downwardly towards said lower position, said slide valve element containing an opening, and a float valve floatable upwardly on a body of liquid relative to said slide valve element to a position in which the float valve element closes said opening in the slide valve element.

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