APPARATUS FOR DISPENSING HIGHLY VOLATILE LIQUIDS

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Liquids of high vapor pressure, such as the liquefied petroleum gas which consists largely of propane and/or butane, are often stored in relatively large quantity in order to be dispensed into truck tanks, automotive vehicle fuel tanks and other smaller containers. For economy of ground space and more particularly for reasons of safety, the storage tanks are usually placed underground, this being in fact a legal requirement in most localities. From these buried tanks the liquid is withdrawn by means of a pump which must usually deliver the liquid at a pressure materially above the vapor pressure.

The use for this purpose of a pump placed at or above the surface of the earth is attended with some difficulty. The liquid body in the storage tank rapidly comes into vapor-pressure equilibrium with the overlying vapors. Thereafter, any attempt to draw liquid from the tank by suction lift from an elevated pump causes more or less vaporization of the liquid in the pump suction pipe, the pressure on the liquid in this pipe being necessarily brought below the vapor pressure in the very act of producing the suction. This vaporization renders the operation of any pump inefficient and uncertain and may entirely prevent the use of the centrifugal type of pump which is most desirable for handling extremely volatile liquids.

This difficulty may be avoided by locating the pressure pump itself at or below the bottom of the tank, as in a deep pit, in a well inside the tank, or in a well exterior to the tank and connected with it by piping. Either of these arrangements, however, is unduly expensive as to installation and renders repairs or replacements awkward and difficult.

A method of lifting the liquid to the pump suction which has had some practical application is to increase the pressure in the vapor space in the storage tank by introducing air or other fixed gas. A serious objection to this method is the obvious explosion hazard resulting from the use of air, which is ordinarily the only gas available for this purpose. Another objection which applies equally to the use of other fixed gases is that these gases slowly dissolve in the liquid and tend to separate therefrom when the pressure is reduced, giving rise to gas pockets and other disturbances to the subsequent utilization of the liquid.

The object of the present invention is to provide means for increasing the pressure in the vapor space of an underground tank to a point materially above the natural vapor pressure of the liquid contained in the tank, without the use of any extraneous material for accomplishing this pressure increase. It is obvious that such increased vapor pressure may be utilized to deliver an unbroken stream of liquid to the suction of a pump located at the surface and to prevent vaporization in this stream, thus ensuring a constant supply of liquid to the suction of the pump and its efficient and dependable operation at all times.

The form of the invention contemplated in the present application is illustrated in the attached drawing, which shows in a diagrammatic manner a suitable assemblage of apparatus.

Referring to the drawing, 1 is a closed storage tank placed materially below the ground level indicated at 2. A filling pipe 3 having a hand valve 4 provides for introducing the volatile liquid body indicated at 5.

A relatively small secondary tank or receiver 6 is placed above ground and is pipe connected in its lower part with the suction of a pump 7. A pipe 8 leads from the lower portion of the receiver to the lower portion of tank 1 and is provided with a check valve 9 arranged to prevent the downward flow of liquid.

A well 10 is formed in the bottom of the tank and in this well is placed an electrical heating element 11. The leads 12 to this element pass out of the tank through a pipe column 13 which extends to a point above the surface of the ground, the leads terminating in a switch 14 from which primary leads 15 extend to a source of electrical energy not shown.

A differential thermometer 16 is provided with two bulbs 17 and 18 placed respectively in the top and the bottom of the tank. This thermometer is operatively connected to switch 14 in such manner that when the temperature difference between the two bulbs reaches a predetermined maximum, the switch will be opened and the supply of current to the heating element interrupted, while the reverse movement will occur when the temperature difference falls below a predetermined minimum.

The heating element is surrounded by a tubular column 19 which is open at both ends and which should be insulated against heat transfer as at 20 for at least that portion of its length which is within the tank proper. This column is carried up within column 13 to a level materially above the top of the tank and is so spaced from the walls of the well 10 at the lower end and from column 18 at the upper end as to permit free passage of fluids into and out of the inner column. It should
also be of sufficient size to permit vapor disengaged on the surface of the heating element to pass upwardly through the liquid in the column without priming. This apparatus functions in the following manner. Heat supplied by the heating element \(11\), which is submerged in the liquid within the inner column \(19\), generates warm vapors which pass upwardly in the column and then downwardly around it in the vapor space of the tank. The insulating layer \(20\) prevents the diffusion of this heat into the body of liquid in the tank but the immediate upper surface of the liquid body becomes heated by contact with these vapors. This upper layer, which cannot diffuse into the liquid body because of the lowering of specific gravity which accompanies its rise in temperature, has a vapor pressure corresponding to its temperature and higher than that of the colder liquid in the lower portion of the tank.

The main liquid body is therefore subjected to a pressure equal to the vapor pressure of the heated upper layer, this pressure tending to force liquid from the body in tank \(1\) into receiver \(6\). In the receiver this tendency is resisted by the vapor pressure of the colder liquid, and as this pressure is lower, actual flow from the tank into the receiver will occur as soon as the temperature difference is sufficient to establish a vapor pressure difference slightly greater than the hydrostatic head of the liquid column in pipe \(8\) and tank \(6\). Granting a proper adjustment of the controlling mechanism of the differential thermometer, the receiver will thus be kept constantly filled with the liquid and pump \(1\) will be flooded and in condition to be started and operated in an efficient and dependable manner at all times.

From the known properties of the material being handled it is possible to calculate the temperature difference which must be maintained between the vapor space and the main body of liquid in the tank to create sufficient pressure difference to force the liquid to the desired level in the receiver. The thermometer once set to operate at this temperature difference will automatically maintain the required differential pressure regardless of changes in the actual temperature of the liquid in the tank which may follow from seasonal variations or other causes.

In some actual experiments on underground storage tanks it has been found that, working with commercial mixtures of propane and butane, it is necessary to maintain a temperature difference of only about 5° Fahr. between the liquid body and the vapor space in order to lift the liquid through twenty vertical feet. On account of the excellent heat insulating properties of ordinary earth the rate of heat dissipation from the storage tank with this small temperature rise is practically negligible and only a very small heat input is required to maintain the desired lifting head. As liquid is withdrawn from the receiver by the delivery pump, it is necessary to supply sufficient heat to generate a volume of vapor equal to the volume of liquid withdrawn.

It is obvious that other sources of heat, such as steam or hot water, could be substituted for the electrical heating system described without departing from the spirit of the invention, and also that the heating element of whatever character need not be placed within the tank but may be placed in an auxiliary vessel connected to the tank by a liquid pipe and a vapor pipe. I consider as my invention to lie broadly in the heating of the vapors in the upper portion of the tank to produce a vapor pressure differential between the upper surface layer of liquid in the tank and the main body therein, this difference being of such magnitude as to provide for discharging liquid from the tank to a point of greater elevation.

I claim as my invention:

1. A storage and delivery system for highly volatile liquids comprising in combination: a closed storage tank; a pump arranged substantially above said tank and having its suction in communication with the lower portion thereof; a chamber communicating at its lower end with the lower end portion of said tank; a heating means within said chamber; a differential thermometer having its responsive elements located respectively in the upper and the lower portions of said tank, and means cooperating with said differential thermometer for controlling the supply of heating fluid to said heating means.

2. A storage and delivery system for highly volatile liquids comprising in combination: a closed storage tank; a pump arranged substantially above said tank and having its suction in communication with the lower portion thereof; means for generating relatively warm vapors of said liquid and for delivering said vapors into the vapor space of said tank, and means for controlling the supply of said vapors to maintain a desired temperature difference between fluids occupying respectively the upper and the lower portions of said tank.

3. A storage and delivery system for highly volatile liquids comprising in combination: a closed storage tank; a pump arranged substantially above said tank and having its suction in communication with the lower portion thereof, and means within said tank and constantly immersed in a fluid therein for maintaining a desired temperature difference between fluids occupying respectively the upper and the lower portions of said tank.

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