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(54) EVAPORATION SYSTEM

(71) We, THE BRITISH OXYGEN COMPANY LIMITED, a British company, of Hammersmith House, London, W.6, England, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to an evaporation system. In particular it relates to the provision of such a system in a container for perishable goods so as to maintain the goods at a temperature below ambient. The system is especially suitable for transport containers, for example railway trucks, road vehicles and portable transport containers.

Previous proposals have been made for cooling an insulated food container by the provision of a source of liquefied gas connected to a thermostatically-controlled valved spray system so as to deliver nitrogen to the container and thus to maintain a temperature at which deterioration of the food is reduced. Such systems have been relatively complex and the low temperatures at which they have been required to operate have given rise to problems in controlling the operation of the thermostat and the valves. The invention relates to a simplified form of cold gas delivery system having the advantage of requiring no moving parts.

According to the invention there is provided an enclosed container fitted with a liquefied gas evaporator for supplying evaporated gas thereto in which the evaporator has a shell constructed of gas-impermeable material, a layer of thermal insulating material, an inlet for liquefied gas and a vapour outlet leading directly to the enclosed space of the container, wherein the location and dimensions of the vapour outlet permit the escape of dense, non-turbulent evaporated gas.

Preferably the mean thermal conductivity of the evaporator is within the range 0.0067 to 0.013 BTU/cu ft/°F hour.

The invention also relates to a method of

preserving perishable goods such as food-stuffs by using an evaporator in an enclosed container holding the goods.

After the evaporator has been filled with a liquefied gas, heat inleak, mostly through the walls of the evaporator, causes the liquefied gas to begin to evaporate and deliver cold gas into the container. The newly-evaporated gas is at a temperature close to that of the liquefied gas and thus has a density greater than gas already present in the container. On being introduced directly into the container in a non-turbulent manner the newly-evaporated gas falls to the lowest possible level in the container and forms a layer of cold gas over the floor of the container or over any contents therein. This layer acts as an insulation blanket and is extremely effective in maintaining at low temperature cold packages such as frozen food cartons. In order to create and maintain the layer it is important to avoid turbulent conditions in the container, such as would be produced by the intermittent spraying of liquefied gas or by the use of solid carbon dioxide as coolant in the container. Formation of the layer is also assisted by locating the evaporator outlet at a high level with respect to the floor of the container. If the evaporator itself is located at a low level with respect to the floor of the container it is preferably provided with a chimney to convey the newly-evaporated gas to a high level with respect to the floor of the container.

We have found that the "packaging" effect of the dense vapour is such that the temperature of the packages is maintained at a substantially constant level. Surprisingly this effect applies both to frozen food (for example at about -18°C) and to chilled food (for example at about $+4^{\circ}\text{C}$). Indeed our trials have shown that the ability of the layer of dense vapour to maintain packages at a reduced temperature is much greater than the heat extraction effect of the liquefied gas. The most important requirement of the container is that it should promote non-

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turbulent conditions. Indeed the insulation of the material of the container can be very small indeed and accordingly it is possible to use a standard transport container having no special insulation.

The evaporator must of course be of a size that can produce the desired volume of dense gas for a given period. With road transport vehicles the period for which gas production is required will normally be within the range 8—12 hours. Preferably a volume of liquefied gas within the range 0.5 to 2.0 kg/hour is evaporated for each cubic metre of the container.

The liquefied gas is preferably liquid nitrogen or liquid argon.

The evaporator shell can be constructed from metal or a plastics material. Examples of particularly suitable materials are aluminium, stainless steel and polytetrafluoroethylene. If desired the shell can be a composite structure of alternate layers of metal and plastics material.

The insulating layer is preferably formed from a solid insulant, for example a foamed plastics material such as foamed polystyrene, and can be in the form of powdered or granular material or of continuous layers or slabs. It is preferably enclosed within an outer shell which, like the inner shell, can be constructed of metal or a plastics material. One particularly suitable solid insulant is a strip of foamed polystyrene wrapped around the inner shell. This allows simple manufacture of the evaporator.

If no outer skin is provided, or only a partial skin, the insulation is desirably so disposed about the shell that there is no exposed part of the shell at a temperature low enough to present a hazard if touched.

The insulating layer can alternatively be provided by a gas such as air or nitrogen in which case an outer shell must be provided to keep the insulating layer in position.

A drip tray is preferably provided at the base of the evaporator and desirably is fitted with a drainage tube to communicate with the exterior of the container.

The interior of the evaporator is preferably fitted with support members. These are helpful in allowing the evaporator to withstand the strains resulting from filling the evaporator at a temperature above 0°C with liquefied gas at a temperature of the order of -200°C. They also act to damp the movement of liquid in the evaporator whilst in motion. The preferred form of support is a perforated baffle plate laterally disposed in the evaporator. At least two such supports are generally desirable.

It has been found that an evaporator of elongated shape mounted with its longest dimension vertical is generally preferred. With such an evaporator the dense evaporated gas flowing downwards over the ex-

ternal surface forms an insulating jacket for the evaporator and thus allows the amount of insulant built into the evaporator to be kept to a minimum. Such an evaporator is preferably of oval horizontal cross section. This allows the evaporator to protrude less into the load carrying space of the container than would a circular cross section and provides a stronger construction than would a square or rectangular cross section.

The vapour outlet is preferably centrally disposed in the upper surface of the evaporator. It is preferably not so small that it is likely to be blocked by ice formation or to cause a turbulent gas stream. For a circular outlet this is likely to occur if a diameter of less than 25 mm is employed. Similarly it should not be so large as to permit large volumes of warm gas to enter and come into contact with the liquefied gas. Thus the area of outlet relative to the area of the upper surface of liquid in the evaporator is preferably within the range 1:8 to 1:80.

Although several outlets can be provided for the evaporated gas it is preferred to employ a single outlet. This helps to give a non-turbulent flow of evaporated gas from the evaporator.

Although the vapour outlet can serve as the liquid inlet, it is generally preferable to provide a liquid inlet separate from the vapour outlet. The evaporator can either be filled when in situ in the container or, if portable, can be filled outside the container and then placed in the desired position in the container. In one convenient form the container is provided with a supply pipe leading from an evaporator inside the container to a supply port outside the container, thus enabling the evaporator to be filled from outside the container.

Any exposed pipes leading to the evaporator should desirably be enclosed in a protective layer. This reduces cold losses from the evaporator and also provides protection against cold burns for anyone who enters the container.

If the evaporator has an inner shell and an outer shell, the upper inner surface of the inner shell is preferably perforated. This ensures that evaporated gas can enter the space between the two shells and thus reduces the possibility that air could be condensed in this space to give liquid air of enriched oxygen content. Such enriched air can prove dangerous if it comes into contact with inflammable material in the space.

The container in which the evaporator is located is preferably provided both with a written warning that gases such as nitrogen and argon, whilst not poisonous, can cause asphyxiation and a written warning that care should be taken when filling the evaporator to prevent build up of pressure in the container.

The invention will now be described with reference to the accompanying drawings, in which:—

Figure 1 is a sectional elevation of one form of evaporator mounted in an insulated container.

Figure 2 is a sectional elevation along the line A—A of the evaporator shown in Figure 1.

Figure 3 is a sectional elevation of a second form of evaporator mounted in an insulated container.

The evaporator shown in Figures 1 and 2 comprises an inner shell 2 constructed of stainless steel enclosed in a shell 4 made up of layers of foamed polystyrene and covered with a coating layer 6 of polypropylene.

An inlet 8 leads into the inner shell 2 and connects with an inlet pipe 10 leading from outside an insulated container 12. The inlet pipe 10 has a valved inlet 14 located outside the container 12. An overflow 16 leads from the upper part of the interior of the shell 2 through a conduit 18 to outside the container 12.

In the top surface of the shell 2 a cylindrical outlet 20 is provided passing through the shell 2 of insulating material and coating layer 6.

The thermal conductivity of the evaporator is 0.0091 BTU/cu ft/°F hour.

The external dimensions of the evaporator are 1.6 metres wide $\times$ 0.4 metres high $\times$ 0.3 metres deep. The inlet pipe 10 is a 25 mm diameter tube and the outlet 20 is a 35 mm diameter cylinder.

In operation liquefied gas is introduced into the shell 2 until the liquid level reaches the inlet of overflow 16. Heat inleak through the walls of the evaporator causes evaporation of the liquefied gas, the dense gas so formed escapes through the outlet 20 into the container 12, and forms a cold insulating blanket over the floor of the container 12 or over any goods therein.

The evaporator shown in Figure 3 has an inner shell 2 of aluminium and of oval cross section covered by an insulating layer 4 made by wrapping first cloth and then polystyrene strip on the inner shell 2. The insulating layer is enclosed within an outer shell 6 of aluminium. The outer shell 6 stands in a drip tray 8 mounted on the floor 10 of the container adjacent to the container wall 12. A circular opening 14 is provided in the centre of the upper end of the shells 2 and 6 and insulating layer 4. The upper surface of the inner shell 2 has perforations as indicated by the numeral 16. Perforated baffle plates 18 are provided inside the inner shell 2. A filler pipe 20 and overflow pipe 22 lead from a hollow boss 24 on the outside of the container wall 12 to the upper part of the inside of the inner shell 2. The filler pipe 20 passes straight

through the boss 24 and is closed by a filler cap 26 fitted with a washer 28. The overflow pipe 22 leads to the inside of the hollow boss 24 and communicates with an overflow port 30.

Insulation 32 is provided around the exposed portions of pipes 20 and 22 and a drain pipe 34 is provided in the base of the drip tray 8, leading through the wall 12 to the outside of the container.

To fill the evaporator the filler cap 26 is removed and liquefied gas from a reservoir is fed into the evaporator. If the evaporator is initially at ambient temperature the liquefied gas initially introduced will evaporate rapidly, providing cold evaporated gas to cool the evaporator and the interior of the container. When the level of liquefied gas reaches the top of the overflow pipe 22 liquefied gas flows through the pipe 22, boss 24 and port 30, indicating that the evaporator is full.

The evaporator described above is 1.8 metres high, of maximum diameter 0.30 metres and the opening 14 has a diameter of 75 mm. It has a mean thermal conductivity of 0.0091 BTU/cu ft/°F/hour at the temperature of evaporating liquid nitrogen (-196°C).

WHAT WE CLAIM IS:—

1. An enclosed container fitted with a liquefied gas evaporator for supplying evaporated gas thereto, in which the evaporator has a shell constructed of gas-impermeable material, a layer of thermal insulating material, an inlet for liquefied gas and a vapour outlet leading directly to the enclosed space of the container, wherein the location and dimensions of the vapour outlet permit the escape of dense, non-turbulent evaporated gas.

2. A container as claimed in claim 1, wherein the mean thermal conductivity of the evaporator is within the range 0.0067 to 0.013 BTU/cu ft/°F hour.

3. A container as claimed in claim 1, or claim 2 wherein the evaporator outlet is located at a high level with respect to the floor of the container.

4. A container as claimed in claim 1 or claim 2, wherein the evaporator is located at a low level with respect to the floor of the container and is provided with a chimney to convey the dense gas to a high level with respect to the floor of the container.

5. A container as claimed in any preceding claim, wherein the evaporator shell is constructed from metal.

6. A container as claimed in any one of claims 1 to 4, wherein the evaporator shell is constructed from a plastics material.

7. A container as claimed in any one of claims 1 to 4, wherein the evaporator shell

The invention will now be described with reference to the accompanying drawings, in which:—

Figure 1 is a sectional elevation of one form of evaporator mounted in an insulated container.

Figure 2 is a sectional elevation along the line A—A of the evaporator shown in Figure 1.

Figure 3 is a sectional elevation of a second form of evaporator mounted in an insulated container.

The evaporator shown in Figures 1 and 2 comprises an inner shell 2 constructed of stainless steel enclosed in a shell 4 made up of layers of foamed polystyrene and covered with a coating layer 6 of polypropylene.

An inlet 8 leads into the inner shell 2 and connects with an inlet pipe 10 leading from outside an insulated container 12. The inlet pipe 10 has a valved inlet 14 located outside the container 12. An overflow 16 leads from the upper part of the interior of the shell 2 through a conduit 18 to outside the container 12.

In the top surface of the shell 2 a cylindrical outlet 20 is provided passing through the shell 2 of insulating material and coating layer 6.

The thermal conductivity of the evaporator is 0.0091 BTU/cu ft/°F hour.

The external dimensions of the evaporator are 1.6 metres wide × 0.4 metres high × 0.3 metres deep. The inlet pipe 10 is a 25 mm diameter tube and the outlet 20 is a 35 mm diameter cylinder.

In operation liquefied gas is introduced into the shell 2 until the liquid level reaches the inlet of overflow 16. Heat leak through the walls of the evaporator causes evaporation of the liquefied gas, the dense gas so formed escapes through the outlet 20 into the container 12, and forms a cold insulating blanket over the floor of the container 12 or over any goods therein.

The evaporator shown in Figure 3 has an inner shell 2 of aluminium and of oval cross section covered by an insulating layer 4 made by wrapping first cloth and then polystyrene strip on the inner shell 2. The insulating layer is enclosed within an outer shell 6 of aluminium. The outer shell 6 stands in a drip tray 8 mounted on the floor 10 of the container adjacent to the container wall 12. A circular opening 14 is provided in the centre of the upper end of the shells 2 and 6 and insulating layer 4. The upper surface of the inner shell 2 has perforations as indicated by the numeral 16. Perforated baffle plates 18 are provided inside the inner shell 2. A filler pipe 20 and overflow pipe 22 lead from a hollow boss 24 on the outside of the container wall 12 to the upper part of the inside of the inner shell 2. The filler pipe 20 passes straight

through the boss 24 and is closed by a filler cap 26 fitted with a washer 28. The overflow pipe 22 leads to the inside of the hollow boss 24 and communicates with an overflow port 30.

Insulation 32 is provided around the exposed portions of pipes 20 and 22 and a drain pipe 34 is provided in the base of the drip tray 8, leading through the wall 12 to the outside of the container.

To fill the evaporator the filler cap 26 is removed and liquefied gas from a reservoir is fed into the evaporator. If the evaporator is initially at ambient temperature the liquefied gas initially introduced will evaporate rapidly, providing cold evaporated gas to cool the evaporator and the interior of the container. When the level of liquefied gas reaches the top of the overflow pipe 22 liquefied gas flows through the pipe 22, boss 24 and port 30, indicating that the evaporator is full.

The evaporator described above is 1.8 metres high, of maximum diameter 0.30 metres and the opening 14 has a diameter of 75 mm. It has a mean thermal conductivity of 0.0091 BTU/cu ft/°F/hour at the temperature of evaporating liquid nitrogen (−196°C).

WHAT WE CLAIM IS:—

1. An enclosed container fitted with a liquefied gas evaporator for supplying evaporated gas thereto, in which the evaporator has a shell constructed of gas-impermeable material, a layer of thermal insulating material, an inlet for liquefied gas and a vapour outlet leading directly to the enclosed space of the container, wherein the location and dimensions of the vapour outlet permit the escape of dense, non-turbulent evaporated gas.

2. A container as claimed in claim 1, wherein the mean thermal conductivity of the evaporator is within the range 0.0067 to 0.013 BTU/cu ft/°F hour.

3. A container as claimed in claim 1, or claim 2 wherein the evaporator outlet is located at a high level with respect to the floor of the container.

4. A container as claimed in claim 1 or claim 2, wherein the evaporator is located at a low level with respect to the floor of the container and is provided with a chimney to convey the dense gas to a high level with respect to the floor of the container.

5. A container as claimed in any preceding claim, wherein the evaporator shell is constructed from metal.

6. A container as claimed in any one of claims 1 to 4, wherein the evaporator shell is constructed from a plastics material.

7. A container as claimed in any one of claims 1 to 4, wherein the evaporator shell



- is a composite structure of alternate layers of metal and plastics material.
8. A container as claimed in any preceding claim, wherein the insulating layer of the evaporator is enclosed within an outer shell.
9. A container as claimed in any preceding claim, wherein the insulating layer of the evaporator is formed from a solid insulant.
10. A container as claimed in claim 9, wherein the solid insulant is a foamed plastics material.
11. A container as claimed in claim 8, wherein the insulating layer is provided by a gas.
12. A container as claimed in any preceding claim, wherein the evaporator is provided with a drip tray.
13. A container as claimed in claim 12, wherein the drip tray has a drainage tube to communicate with the exterior of the container.
14. A container as claimed in any preceding claim, wherein the interior of the evaporator is fitted with support members.
15. A container as claimed in claim 14, wherein the support members are perforated baffle plates laterally disposed in the evaporator.
16. A container as claimed in any preceding claim, wherein the evaporator is of elongated shape with its longest dimension vertical.
17. A container as claimed in claim 16, wherein the evaporator is of oval horizontal cross-section.
18. A container as claimed in any preceding claim, wherein the vapour outlet is centrally disposed in the upper surface of the evaporator.
19. A container as claimed in any preceding claim, wherein the area of the vapour outlet relative to the upper surface area of liquid in the evaporator is within the range 1:8 to 1:80.
20. A container as claimed in any preceding claim, having a single vapour outlet in the evaporator.
21. A container as claimed in any preceding claim, wherein the liquid inlet for the evaporator is separate from the vapour outlet.
22. A container as claimed in any preceding claim, having a supply pipe leading from the evaporator to a supply port outside the container.
23. A container as claimed in any preceding claim, wherein any pipes leading to the evaporator are enclosed in a protective layer.
24. A container as claimed in any preceding claim, wherein the evaporator has an inner shell and an outer shell and the upper inner surface of the inner shell is perforated.
25. A container as claimed in claim 1, substantially as described herein with reference to Figures 1 and 2.
26. A container as claimed in claim 1, substantially as described herein with reference to Figure 3.
27. A method of preserving perishable goods employing a container as claimed in any preceding claim.
28. A method as claimed in claim 27, wherein 0.5 to 2.0 kg/hour of liquefied gas is evaporated for each cubic metre of the container.
29. A method as claimed in claim 27 or 28, wherein the liquefied gas is liquid nitrogen.
30. A method as claimed in claim 27 or 28, wherein the liquefied gas is liquid argon.
- For the Applicants,
PETER JACKSON,
Chartered Patent Agent.

