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[54] **SEALED PACKAGE CONTAINING FROZEN LIQUID**

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[52] **U.S. Cl.** **62/1**

[51] **Int. Cl.** **F25c 1/00**

[58] **Field of Search** 62/1, 60, 62, 374

[56] **References Cited**

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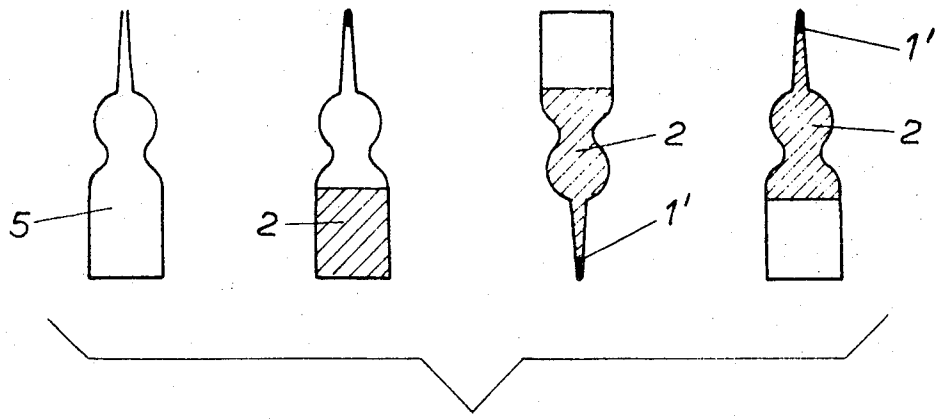
[57] **ABSTRACT**

A package of frozen liquid, particularly an aqueous liquid, is produced by partially filling a container with liquid, closing the container, and so positioning the liquid in the container that it immerses the closure and separates the closure from the gas in the container. The liquid is then frozen, and forms in effect an additional closure for the container. The gas in the container is preferably under superatmospheric pressure. If the liquid is aqueous, then its volume is so regulated relative to the volume of the gas in the container, that the liquid upon freezing will expand by a volume which is at least 30% of the volume of the gas in the container. The invention prevents the entry of further gas into the container.

1 Claim, 4 Drawing Figures



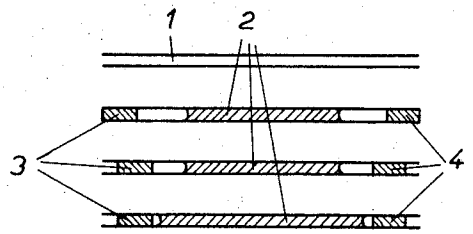


Fig. 1

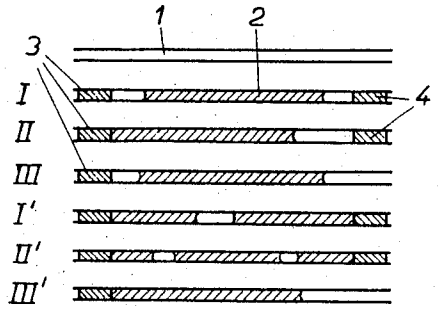


Fig. 2

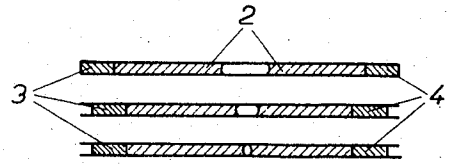


Fig. 3

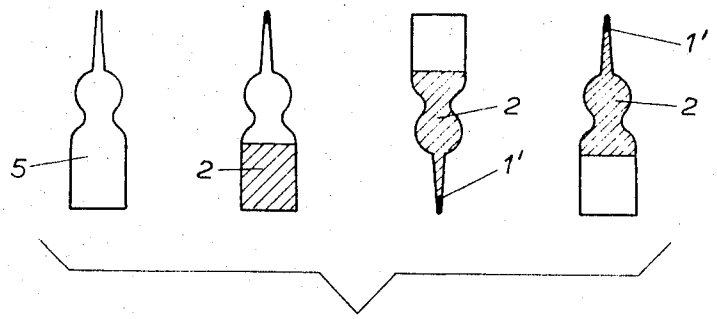


Fig. 4

SEALED PACKAGE CONTAINING FROZEN LIQUID

The present invention relates to a sealed package containing a frozen liquid, more particularly an aqueous liquid, for example animal sperm. The present invention also relates to methods for forming the sealed package of frozen liquid.

The known packages and methods of forming them involve the use of a container which is either totally or partially closed. It is known that the closure zones of such receptacles of the prior art, which are effective for sealing purposes above, say, 220° K., lose at least a part of their sealing effectiveness when they are subjected to lower temperatures.

In particular, in such a receptacle containing both frozen liquid and a gaseous phase, the lowering of temperature of the gaseous phase is accompanied by a reduction of its pressure. Any defect in the closure, regardless of its origin, and even the deformation of the package under the action of lower temperature, can result in a leak of gas from outside the package into the package.

Then, when the receptacle is again raised in temperature, the pressure of the gaseous phase will be greater than the original pressure of the gaseous phase, all other things being equal. This increased internal pressure will in certain cases open the closure or expel part or all of the contents of the receptacle, or even rupture the package. The liquid phase will in this way be subjected to partial or total loss or deterioration.

Accordingly, the present invention has as its object to overcome the above difficulties and disadvantages, by using characteristics of the frozen liquid itself, to improve the seal of the package.

Two characteristics of the frozen liquid can be used, either separately or conjointly, to do so, as follows:

In the first place, the volume of an aqueous liquid increases upon freezing; and in the second place, once frozen, the liquid itself can be used as a closure for the receptacle.

The invention therefore has as its further object the use, either separately or simultaneously, of these two properties of frozen liquids, particularly aqueous liquids, so as to avoid passage of gas from outside the container into the container.

To utilize the first of these properties, namely, the expansion of an aqueous liquid upon freezing, the volume of gas above the liquid in the container is reduced so that the increase of volume of the aqueous liquid upon freezing will be at least 30 percent of the volume of the gas in the container. This can be done by compressing the gas or by increasing the amount of aqueous liquid relative to the gas.

The second property recited above, by which the frozen liquid itself can serve as a closure, is utilized by immersing the closure or seal of the package in the liquid contained in the package before freezing the liquid. After freezing, the frozen liquid forms in effect a plug that augments the seal.

A still further object of the present invention is the provision of a package of frozen liquid whose seal against the ingress of gas is reinforced by one or the other or both of the above principles.

Other objects, features and advantages of the present invention will become apparent from a consideration of the following description, taken in connection with the accompanying drawing, in which:

FIG. 1 is a chronologically stepwise diagram, proceeding from top to bottom, showing one embodiment of the invention;

FIG. 2 is a view similar to FIG. 1 showing two further sequences of application of the invention;

FIG. 3 is a view similar to FIG. 1 showing still another embodiment of the invention; and

FIG. 4 is a diagrammatic view showing still another embodiment of the invention.

Referring now to the drawing in greater detail, and first to the embodiment of FIG. 1, there is shown an empty receptacle 1, which is partially filled by a liquid 2 and closed at its two ends by plugs 3 and 4. The pressure of the gas inside the container is elevated by forcing the plugs 3 and 4 toward each other.

The liquid 2 is then frozen, and because it is aqueous, it expands and further reduces the volume occupied by the gaseous phase. However, as the pressure of the gas tends to fall with temperature, the pressure-volume relationships of the gas are not predictable from Boyle's Law. The liquid's volumetric expansion during freezing is at least 30 percent of the volume of the gas. It will of course be understood that the four horizontal bars in FIG. 1 are sequential timewise, from top to bottom.

FIG. 2 shows another general procedure according to the present invention, with three variations thereon. In FIG. 2, as in FIG. 1, one starts with the empty vessel 1, and adds one or two plugs 3 and 4 and fills with aqueous liquid 2, in the three manners shown on the diagrams I, II and III. Thus, in I, the liquid is initially spaced from both plugs 3 and 4; while in II, the liquid immerses the plug 3 but not plug 4. In III, only a single plug 3 is used.

The next steps in FIG. 2 are shown for each case by the diagrams I', II' and III', respectively, during freezing. In each case, the two closures (I' and II') or the single closure (III') are or is immersed in the liquid during freezing. The frozen liquid thus acts as a seal to augment the sealing effect of the plug or plugs.

Still another procedure according to the invention is shown in FIG. 3, in which the liquid phase 2 is introduced and maintained in a manner so as to immerse both plugs 3 and 4, with the gas phase spaced from both closures. Upon freezing, the gas phase is further reduced by the expansion of the freezing liquid.

To immerse a single plug, the receptacle can be so positioned that the liquid occupies the desired position under the influence of gravity. To immerse plural spaced plugs, the receptacle can be rotated about an axis equidistant from the plugs, so that the liquid occupies the desired position during freezing under the influence of centrifugal force.

FIG. 4 shows sequential steps in a process according to the present invention using a receptacle 5 in the form of a bottle. In this case, the empty bottle 5 is successively partially filled with a liquid 2, closed at its end 1', and inverted in such a way that the liquid is in contact with the closed end 1' during freezing. After freezing, the frozen liquid forms a plug that augments the seal and prevents all introduction of material from the outside to the inside of the receptacle, even when the receptacle is reinverted for storage as shown in the last of the diagrams of FIG. 4.

The present invention thus permits the augmentation of the fluidtight seal of packages of frozen liquid products, particularly aqueous liquid products.

From a consideration of the foregoing disclosure, therefore, it will be evident that all of the initially recited objects of the present invention have been achieved.

Although the present invention has been described and illustrated in connection with preferred embodiments, it is to be understood that modifications and variations may be resorted to without departing from the spirit of the invention, as those skilled in this art will readily understand. Such modifications and variations are considered to be within the purview and scope of the present invention as defined by the appended claims.

Having described my invention, I claim:

1. A sealed package containing gas and a completely frozen aqueous liquid, the package having a closure, the frozen liquid occupying all of the package adjacent the closure, the gas in the package being spaced from the closure by the frozen liquid, the proportion between the quantity of frozen liquid and the quantity of gas being such that the volume by which the aqueous liquid expands during freezing is at least 30 percent of the volume of the gas prior to the freezing of the aqueous liquid.

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