United States Patent

Hales et al.

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[54] **LIQUID NITROGEN REFRIGERATION SYSTEM**

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[73] Assignee: **Shipowners Refrigerated Cargo Research Association,** Cambridge, England

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[30] **Foreign Application Priority Data**

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[51] **Int. Cl.**.....**F25b 19/00**

[58] **Field of Search**.....62/514, 157, 158, 222, 216, 62/223, 231

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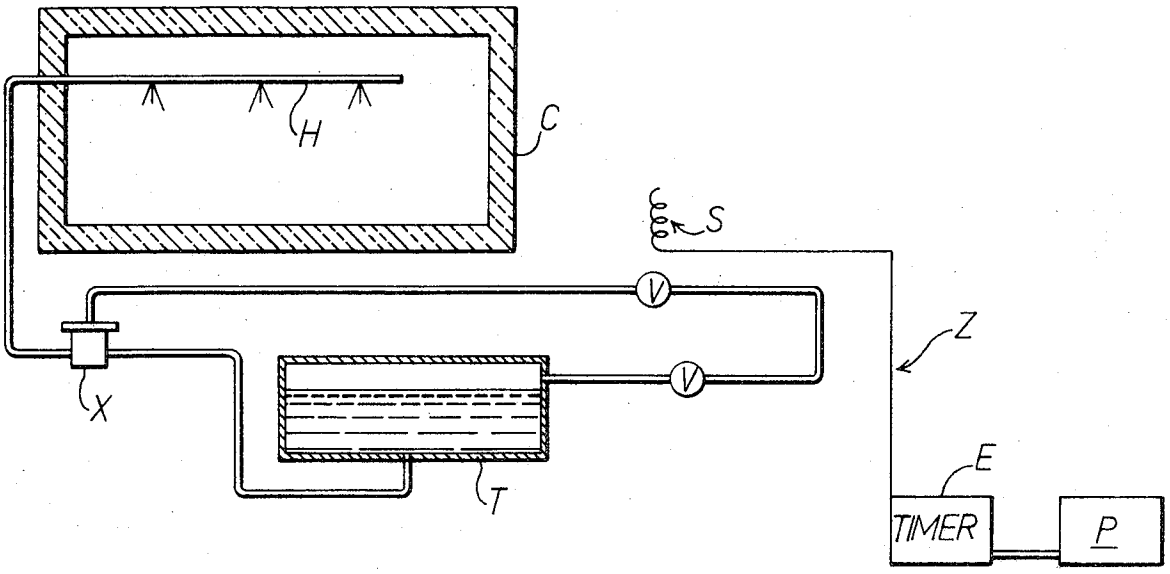
[57] **ABSTRACT**

The invention relates to a refrigeration system for a cargo container and a method of refrigerating the container in which the interior of the container is connected with a reservoir of liquid nitrogen, a control valve is provided between the container and reservoir to control admittance of nitrogen to the container and the control valve is caused to be opened and closed for predetermined time intervals. The control valve is opened and closed automatically by a timing device, which is preferably powered by pressure from within the reservoir of nitrogen. However, the timing device may be of any, known type.

3 Claims, 4 Drawing Figures



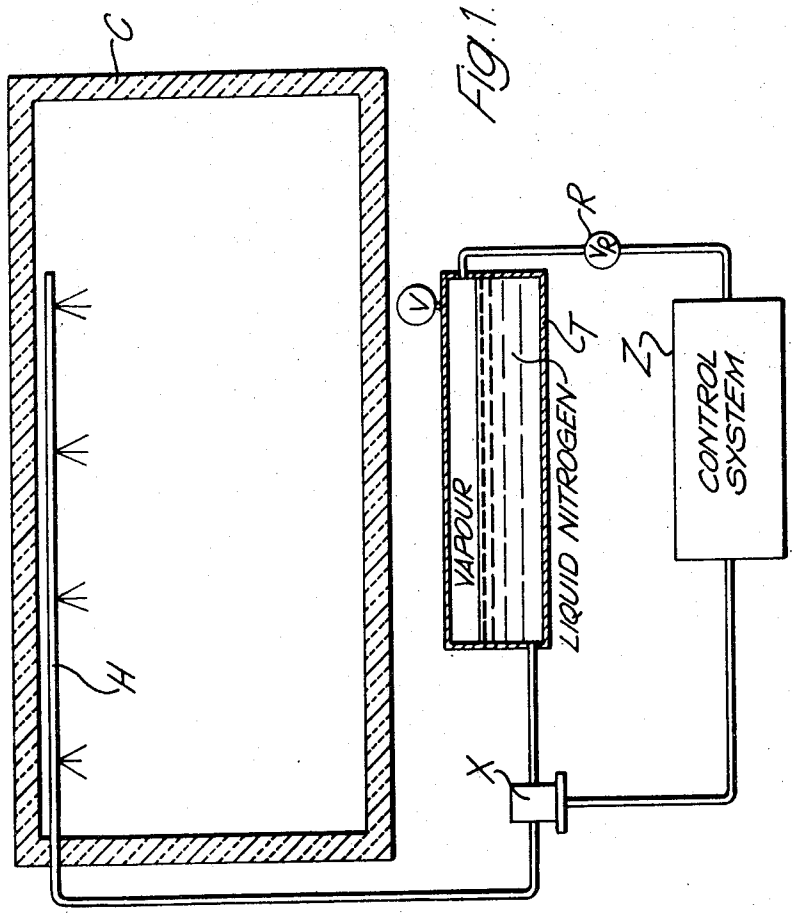


FIG. 1

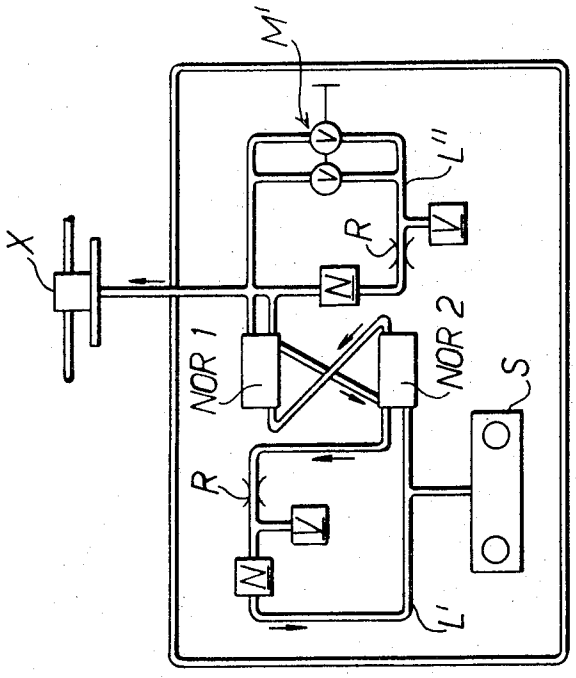


FIG. 4.

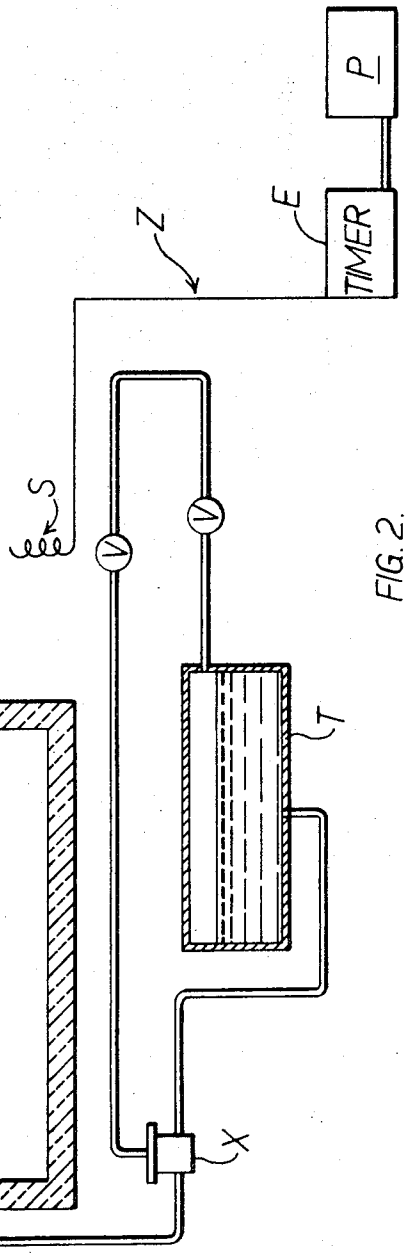


FIG. 2.

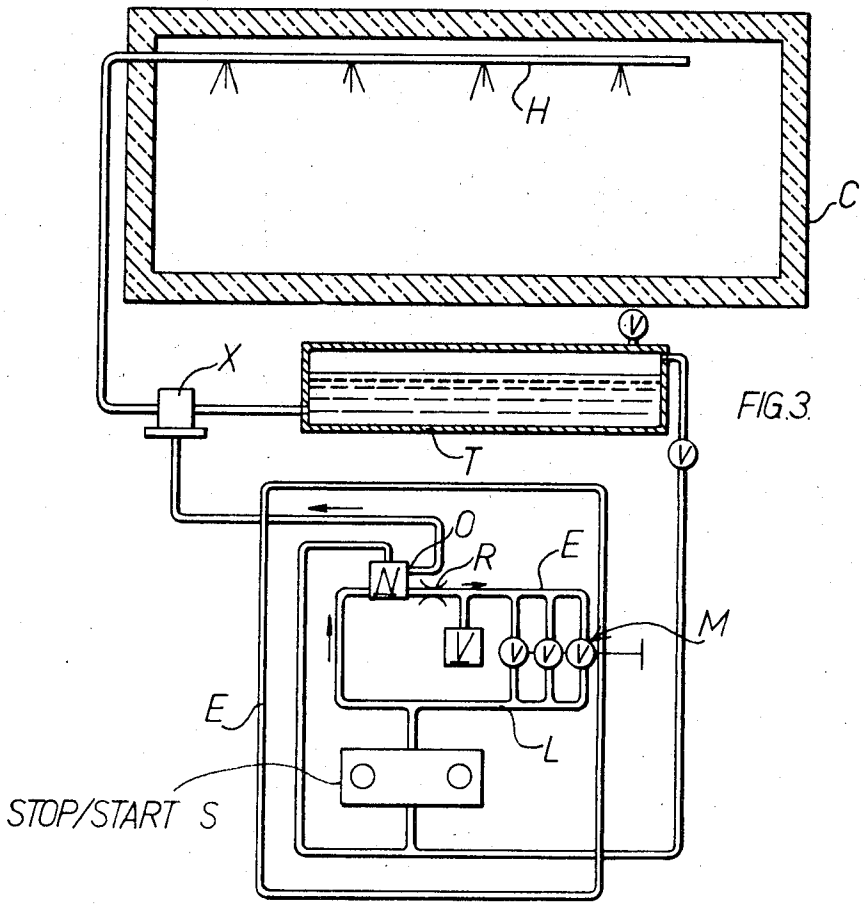


FIG.3

LIQUID NITROGEN REFRIGERATION SYSTEM

This invention relates to the refrigeration of transportable containers. It is especially concerned with the refrigeration of containers which are used for the intercontinental transport of commodities where a low temperature and/or low humidity must be maintained inside a container irrespective of wide variations in the external temperature and humidity and notwithstanding handling by different forms of transport.

According to the present invention a refrigeration system for a container of the kind specified comprises a reservoir containing liquid nitrogen, pipe means adapted to connect said reservoir to the container, valve means in said pipe means arranged to admit pulses of liquid nitrogen into the container and control means adapted to open and close said valve for predetermined time intervals.

Preferably said valve means and control means are physically attached to the liquid nitrogen reservoir for compactness.

Also according to the invention, we provide a method of refrigerating a cargo container of the kind specified comprising connecting the interior of the container with a reservoir of liquid nitrogen, providing acontrol valve between the container and reservoir to control admittance of nitrogen to the container and causing the control valve to be opened and closed for predetermined time intervals.

In its simplest form, the control means merely comprises a timing device to open and close the control valve at preset time intervals. Alternatively, the control valve may be pressure operated, in which case, a further fluid line extends from the top of the liquid nitrogen reservoir to the control valve and the pressure operated control valve is powered by pressurized gas from the space above the liquid nitrogen in said reservoir. In this arrangement a further valve may be provided in the further fluid line, controlled by a timing device. This further valve may be a solenoid operated valve. The timing device may be electrically or electronically operated, pressure operated, e.g. a controlled build up of pressure to a predetermined maximum giving a signal at intervals, or clockwork or battery operated, or fluidic control systems such as those described in our copending U.S. Pat. application Ser. No. 83,722 filed Oct. 26, 1970 now U.S. Pat. No. 3,673,810 could be used.

Several embodiments of the invention will now be described with reference to the accompanying drawings, in which:

FIG. 1 shows schematically a container fitted with a refrigeration system according to the present invention, and

FIG. 2 shows schematically an electrical valve control arrangement for use in the system of FIG. 1, and

FIG. 3 and 4 show schematically two alternative fluidic logic control arrangements.

Referring to the drawings, FIG. 1 shows a refrigeration system in which a valve X controls the flow of liquid nitrogen from a cylinder T to a spray header H placed inside an insulated container C. A control system Z is supplied with gas pressure from the top of the nitrogen cylinder T via a reducing valve R. An output from the control system opens and closes the valve X.

According to one embodiment of the invention shown schematically in FIG. 2, supply of nitrogen to the spray header H is controlled electrically. The control system Z of FIG. 2 includes a solenoid operated valve S in the pressure fluid line between the nitrogen vapor in the top of the tank T and the pressure operated control valve X. The valve S is simply turned on and off for equal predetermined time intervals by an electric or electronic timer E obtaining its power from a power supply P, thereby opening and closing the valve X for predetermined intervals of time.

In a simplified version of the embodiment of FIG. 2, the control system Z merely comprises a timing device which may be electrically or clockwork operated or operated by other means directly to open and close for predetermined periods of time the control valve X. It will be appreciated that in the embodiment of FIG. 2, the timer E may be operated mechanically, on a time clock principle of operated in other manner. It will be appreciated, however, that in the preferred arrangements, the vapor pressure of the nitrogen in the cylinder T is used to power the control system. Alternative control systems are shown in FIGS. 3 and 4 and described more fully in our co-pending application Ser. No. 83,722, now U.S. Pat. No. 3,673,810. Generally speaking, however, the alternative control systems are of the fluidic type. On pressing a start button, a fluidic delay device is set in motion and a signal pressure is applied to the valve X which opens the valve and causes liquid nitrogen to flow into the container. After a suitable predetermined interval of time, the valve is closed and liquid nitrogen ceases to flow. There is then a further time delay before the sequence is repeated. On pressing a stop button, the time sequence is interrupted and no further output signals are made to the valve X. In the event of failure of the control system, a zero output pressure to valve X closes the valve.

The control system is such that the timing sequence can be varied according to the ambient temperature surrounding the container. This ambient temperature can be used, by making use of thermostats, automatically to vary the time delay of the fluidic delay units thereby controlling the time during which the valve X is opened. Such automatic control can also be used with the FIG. 2 embodiment.

In the embodiment shown in FIG. 3, a NOR logic unit N employing two inputs and two outputs is connected to a restrictor R and a volume V and in series with an equal number of similar NOR units complete with restrictors and volumes to form a closed loop L. An output O from the NOR UNIT N is connected to and controls the valve X. The system produces equal on and off timing intervals and the total cycle time can be increased or decreased by the use of multiport valve M for switching into and out of the closed loop further pairs of NOR units complete with restrictors and volumes in series thereby shortening or lengthing the circuit and hence the time delay produced by the circuits. The multiport valve M can be set either manually or automatically according to the ambient temperature surrounding the container C.

In the embodiment of FIG. 4, the cycle of operations is initiated by a conventional stop start system S which uses two NOR logic units NOR1, NOR2, cross connected to provide a simple flip-flop. A closed loop L',

L'', respectively comprising an equal number of NOR units, volumes and restrictors arranged in series is connected to the output of each NOR unit and upon applying a start signal to the NOR unit NOR 2, an output from the other NOR unit NOR1 opens the valve X and the series NOR units in the closed loop L'' with their respective volumes and restrictors control the duration of the valve opening. When this output is fed back to the other NOR unit NOR1 as an input signal, an output signal from the NOR unit NOR2 goes through the respective delay NOR units with their restrictors and volumes in the loop L' until it is fed back as an input, thereby automatically restarting the cycle. The time delay can be varied by switching in, by means of a multiport valve M', further pairs of NOR units into one or both of the closed loops L', L'' as in the embodiment of FIG. 3, or by varying the volume in series with any NOR unit.

What is claimed is:

1. A refrigeration system for a container comprising a reservoir containing liquid nitrogen and nitrogen vapor, first pipe means for conducting liquid nitrogen from said reservoir to said container, a control valve in said first pipe means arranged to admit pulses of liquid nitrogen into the container, control means for opening and closing said control valve for predetermined time intervals, said control means includes a portion thereof disposed in second pipe means for conducting nitrogen vapor from said reservoir to said control valve, said control valve being responsive only to pressure of said nitrogen vapor in said reservoir to admit pulses of liquid nitrogen into the container through said first pipe means, said control means portion is a valve in said second pipe means controlled by a timing device, and said timing device is electrically operated.

2. A refrigeration system for a container comprising a reservoir containing liquid nitrogen and nitrogen vapor, first pipe means for conducting liquid nitrogen from said reservoir to said container, a control valve in said first pipe means arranged to admit pulses of liquid nitrogen into the container, control means for opening and closing said control valve for predetermined time intervals, said control means includes a portion thereof disposed in second pipe means for conducting nitrogen vapor from said reservoir to said control valve, said control valve being responsive only to pressure of said nitrogen vapor in said reservoir to admit pulses of liquid nitrogen into the container through said first pipe means, said control means portion is a valve in said second pipe means controlled by a timing device, and said timing device is electronically operated.

3. A refrigeration system for a container comprising a reservoir containing liquid nitrogen and nitrogen vapor, first pipe means for conducting liquid nitrogen from said reservoir to said container, a control valve in said first pipe means arranged to admit pulses of liquid nitrogen into the container, control means for opening and closing said control valve for predetermined time intervals, said control means includes a portion thereof disposed in second pipe means for conducting nitrogen vapor from said reservoir to said control valve, said control valve being responsive only to pressure of said nitrogen vapor in said reservoir to admit pulses of liquid nitrogen into the container through said first pipe means, said control means portion is a valve in said second pipe means controlled by a timing device, and said timing device is clockwork operated.

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