

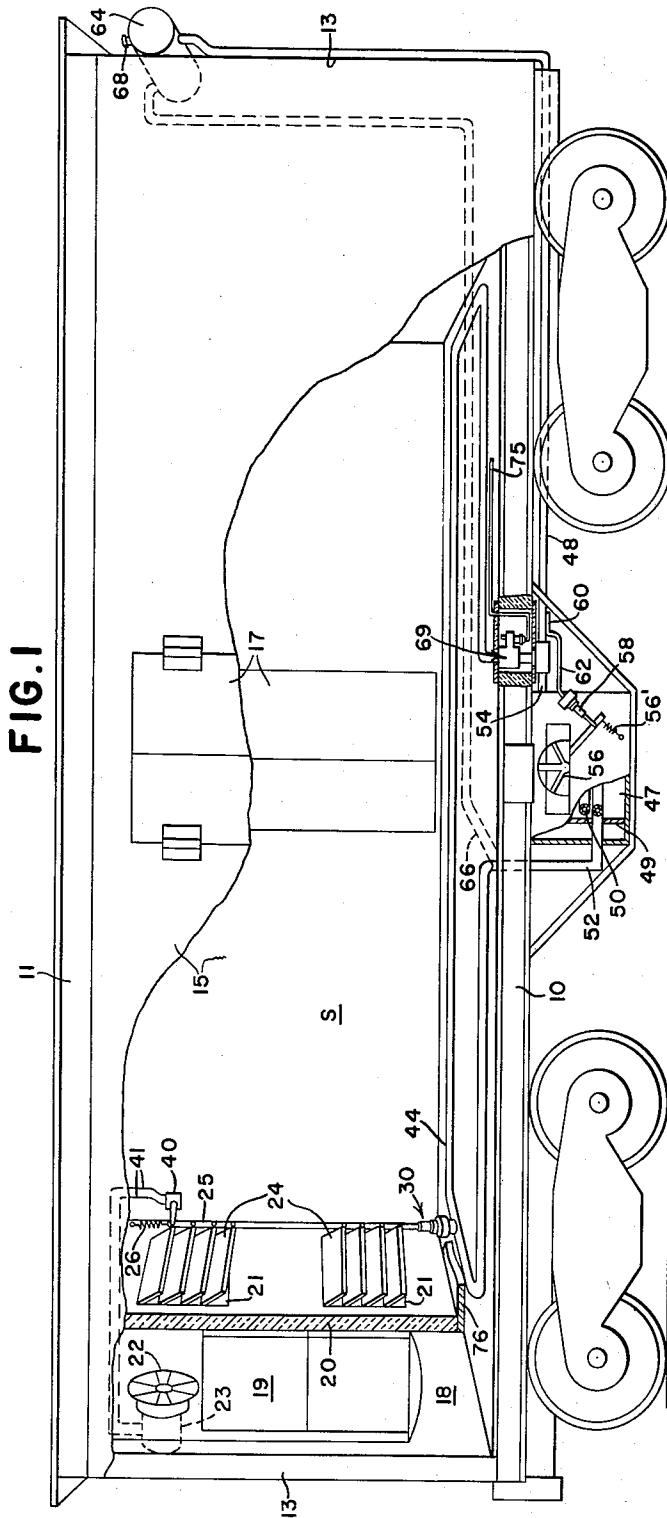
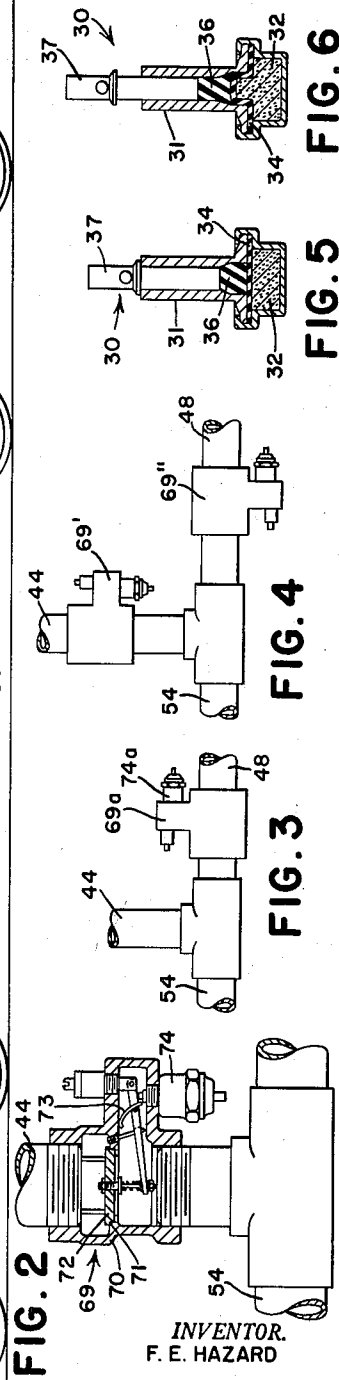
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TEMPERATURE-CONTROLLED SYSTEM FOR TRANSPORT CONTAINERS

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TEMPERATURE-CONTROLLED SYSTEM FOR TRANSPORT CONTAINERS

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This invention relates to the transportation of perishables such as food and the like by means of containers such as railway cars motor trucks, etc., and more particularly to the control of critical temperatures involved in the conserving of quality and condition of the lading.

It is known of course to refrigerate transport containers to protect and preserve produce and other commodities in transport against high ambients, as in warm climates, and it is also known to supply heat to containers as protection against low ambients during travel through low-temperature climates. In situations of this nature relatively substantial variations in temperature may occur in the container en route because of variations in ambient and/or loss of efficiency of the refrigerating or heating system, resulting in serious damage to the shipment from over-refrigeration or over-heating. However, the basic problem is not one of simply refrigerating or heating but of providing optimum temperatures for preserving top quality of the shipment and regulating ripening at a rate commensurate with delivery of the produce in condition to meet the demands of the market. Without proper control, such as afforded by the present invention, shippers' losses for spoilage and deterioration continue to increase and national food waste is aggravated. Added to these problems are those arising from the economical necessity of using a container for a variety of commodities at different times and the desire to achieve satisfactory results, according to one phase of the invention, by a system by which conventional transportable containers may be converted at small expense, thereby avoiding the imminent obsolescence of current equipment. Attempts to solve these problems by mechanical refrigeration incorporating a reverse cycle have been, in the main, commercially unfeasible because of initial cost and expensive maintenance.

Accordingly, it is a principal object of this invention to provide a novel system of temperature control, for the purpose stated, involving a balance of heat and cold relative to the particular commodity or perishable transported and relative to varying ambients en route. It is a significant object to relate several temperature-changing and temperature-controlling means in a unified system. Another object is to provide such system that may be economically exploited by conversion of existing types of transport containers, especially those refrigerated by water-ice, Dry-Ice, brine, etc. such as cars having end or overhead bunkers. Further objects reside in a novel by-pass arrangement for a heated liquid-circulating system, improved control of the cooled air circulation during the refrigeration phase and regulation of the heater output for the liquid circulating portion of the system, the novel use of throttling valve arrangements for main and by-pass liquid lines, and the novel use of "hydraulic thermostats" as control actuators.

Fresh fruit and vegetable growers are at present demanding thermostatically controlled containers, but, as far as can be ascertained, such aim can be fulfilled only by expensive and complicated refrigeration systems of the mechanical or absorption types. Even these are alone

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unsuitable for securing temperatures in the high and intermediate ranges; viz., 60–70° F. Water-ice, Dry Ice and brine-cooled cars are adequate only in conditions in which the cooling thereby can be "balanced" against a relatively high ambient, and even then any fairly suitable "control" can be obtained only manually, as by opening hatches, adding ice, etc.

The foregoing and other important objects and desirable features inherent in and encompassed by the invention will become apparent as a preferred embodiment, together with variations of certain phases of the basic invention, is disclosed by way of example in the ensuing specification and accompanying drawing, the several figures of which are described below.

Figure 1 is a cutaway perspective, partly in section, of a railway car incorporating the improved system.

Figure 2 is an enlarged sectional view of a preferred type of throttling control valve for the main and by-pass lines.

Figures 3 and 4 are enlarged sectional views of modified forms of flow control valve arrangements for the main and by-pass lines.

Figures 5 and 6 are sectional views of a preferred form of "hydraulic thermostat" for controlling the cooling compartment louvres and the heater damper.

The railway car shown is representative of a transportable container and has a floor 10, a roof or ceiling 11, end walls 13, and side walls 15, all suitably insulated. Access to the interior of the car is had via typical side doors 17. Each end of the car is conventionally equipped with a cooling compartment 18, only one of which is shown, here in the form of a bunker adapted to contain water-ice, for example, as at 19, as a refrigerating or cooling medium. It should be understood of course that the present system is applicable whether the bunkers are overhead or otherwise located, or even where other forms of refrigeration are employed, whether water-ice, Dry Ice, brine, etc. as the primary refrigerant, as well as to cooling systems of mechanical or other types. In the present case, as a typical but preferred example, a partition 20 separates the compartment 18 from the interior or lading space S of the container and may have either or both upper and/or lower openings 21 that communicate with the container interior S for the circulation of cooled air, which circulation may be accelerated by a power-driven means such as a fan 22 driven by any suitable means, here an electric motor 23. Upper and lower closure means or louvres 24 are arranged to selectively open or close the openings 21 and are linked together by a control link 25 for simultaneous operation by an actuator 30. The present invention features louvre control by a "hydraulic thermostat" or temperature-responsive device or thermostat best shown in Figures 5 and 6 as comprising a housing 31 containing a temperature-responsive substance, such as a special amalgam at 32, which operates via a diaphragm 34 and elastomer plug 36 to extend and retract a plunger 37. This device is responsive to temperature changes in a main line 44 and is shown as being in direct contact with that line. These devices are capable of transmitting substantial forces in proportion to their size. In the case of the electrically driven fan 22, the linkage 25 is adapted to control an electrical switch 40, connected to the fan motor 23 as at 41, so that the fan starts and stops respectively according to whether the louvres are open or closed. As a variation, the device 30 may directly control the fan and the presence or absence of fan-induced air currents will automatically incur opening and closing, respectively, of the louvres. Each compartment 18 and its refrigerating content (here water-ice 19) constitutes refrigerating means or means for extracting heat from the lading compartment or container S, and the louvres and the control

thereof, together with the fan if the fan is used, constitute control or regulating means for said refrigerating means.

As already indicated, the car has a similar bunker or compartment at its other end and that bunker will be equipped like that just described.

The car carries amidships a heating means, here in the forms of what is conventionally known as an under-slung heater 47 for heating liquid to be circulated selectively through the main heater or liquid line 44 or a by-pass line 48. The particular heater shown is of the type having a fire pot 49 in which suitable fuel, preferably charcoal or anthracite, is burned to heat a liquid heating means or coil 50 which has its inlet 52 and outlet 54 connected respectively to opposite ends of the main line 44. Other types of heaters are not excluded but experience with that disclosed here has demonstrated its efficiency and economy.

The liquid employed may be ethylene glycol and water or any other suitable for the purpose. As will be seen, the main line is within the compartment and overlies the floor 10. The heater itself is external to the compartment and the floor is appropriately insulated as are, of course, the walls and roof of the car. Charging and other maintenance of the heater may be conducted outside the car. The output of the heater is here regulated by a control means such as a regulator or damper 56, for example, under control of a regulator actuator 58, which is here a hydraulic thermostat identical to the louvre actuator 30 except that it is responsive at 60 to temperature changes in the by-pass line 48 via a signal line 62.

The by-pass 48 is external to the compartment and runs under the floor to one end of the car whence it extends up to a suitable expansion tank 64, returning at 66 to the return side 52 of the heater. The by-pass is thus located conveniently and out of the way of possible damage, and the expansion tank, having a capped filler neck 68, affords ready means by which the liquid part of the system may be filled. The principal purpose of the substantial length of the by-pass is to afford a major radiation surface outside the car.

The by-pass 48 has appropriate connections to the main line 44, the return connection being effected as by a simple T and the connection at the outlet side being made by a flow control valve 69 as best shown in Figure 2. This valve is of the throttling type having a valve body 70, a valve seat 71 and a movable valve member 72 which is spring loaded at 73 to close and which opens via a temperature-responsive device 74 responsive to container temperatures via a mercury bulb or tube 75, hereinafter referred to as a thermostat 74-75. An overlying walk or secondary floor, a portion of which appears at 76, is commonly used to protect the main line 44.

The valve 69 in one form of arrangement (Figures 1 and 2) is at the junction of the outlet 54 and the lines 44 and 48 and operates to throttle fluid flow through the main line 44 as the valve closes that line, until ultimately, that line is blocked and the by-pass line 48 is open. Figure 3 shows a variation by way of a valve 69a in the by-pass line and which therefore never positively closes the main line 44 but which depends upon cutting out the main line in effect on the principle that when the valve 69a is open the heated liquid will follow the by-pass line 48 as the line of least resistance. An actuator device 74a, like that at 74, controls the valve 69a. A further modification appears in Figure 4, in which case two valves 69' and 69'' positively close the main and by-pass lines respectively, both being responsive but in opposite phase to temperature changes in the container, as via the thermostat 74-75; i.e., when the valve 69' is open the valve 69'' will close, and vice versa. It is obvious of course that a suitable three-way valve could be designed to accomplish the same purpose. The throttling action achieves a nicety of control which adequately balances the system during temperature changes. It will be clear

that the valves 69a, 69' and 69'' are similar to the valve 69.

In operation, the temperature-responsive devices or thermostats 30, 58 and 74-75, which are of course typically adjustable, are set to respond to temperature changes above and below a predetermined value initially selected on the basis of the temperature recommended for a particular commodity, such as those covered by Handbook 66, USDA. It is preferred that any known indicator be used outside the car to show actual container temperature, recommended container temperature and even the current ambient if desired. If the system is operating properly, the actual container temperature and the recommended temperature will of course be the same. For example, the safe shipment of some perishables may require a temperature somewhat above freezing, e.g., 50° F., from which it will be seen that refrigeration alone will not be satisfactory, except possibly in those cases in which manual regulation of hatches, etc. dissipates some of the refrigeration effect to a high ambient. There is, of course, an upper limit also on these recommended temperatures and heating alone is not enough, unless it can be balanced against a low ambient. But ambients vary and manual operation, even if skilfully employed, is hazardous at best. As will appear below, this guesswork and other disadvantages are eliminated by the inventive control system herein disclosed and claimed.

If above-freezing container temperatures are required, say 37°-39°, the bunkers are charged with water-ice, for example, and the heater is charged with fuel and lighted because refrigeration alone would drop the temperature too low. If the current compartment temperature is above the predetermined value, the thermostat 74-75 acts on the valve 69 to cut out the main line 44 and to cut in the by-pass 48 via the valve 69; the hydraulic thermostat 58, responsive to temperature rise in the by-pass line 48 is operative through the damper or regulator 56 to cut down heater output; and the hydraulic thermostat 30 via the linkage 34, opens the louvres 24 and starts the fan 22, if the fan is used, it being understood that cool air will circulate to some extent without the fan. Excessive temperature drop is avoided because, when the thermostat 74-75, for the valve 69, indicates a need for heat, the valve 69 will open to begin the circulation of heated liquid through the main line 44 instead of through the by-pass line 48. As the by-pass line cools, the damper thermostat 60 responds to the temperature drop and causes the damper 56 to open. At the same time, temperature rise in the main line 44 affects the hydraulic thermostat 30 for the louvres 24 and closes the louvers and also cuts out the fan 22 via the switch 40. The closed louvres not only cut out the refrigerating effect of the refrigerating means but also prevent excessive melting of the ice by the application of heat to the space S.

When the container temperature tends to increase beyond the selected level, the throttling valve 69 closes via the thermostat 74-75 and the main line ultimately cools, whereupon the hydraulic thermostat 30 opens the louvres 24 and starts the fan 22. As the valve 69 closes, the by-pass line temperature rises and the thermostatic device 58 closes the damper 56 and cuts down the heater output. In general, the same results follow when either of the valve arrangements of Figures 3 or 4 are used instead of that of Fig. 2, and it is therefore considered unnecessary to describe in detail the operation of these modifications.

In order to further augment the dependability of the system in case of failure of the devices 30 and 58 for example, the louvres are biased to open position, as by a spring 26, and the damper 56 is biased to open position as by a spring 57'. In either case the excessive refrigeration or excessive heat would be balanced and the only disadvantage would be waste.

It should be understood that cooling to a minimum

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temperature depends upon the capacity of the bunkers, the nature and quality of the insulation in the car and to some extent upon the current ambient. Extremely high ambients can be accommodated only by adding more ice, for example, or by proper regulation of the system where refrigeration of mechanical or other types are employed. But it is in the prevention of excessive cooling that the present system excels, which is significant in the transport of perishables whose preserving temperatures are above 32° F. It is expected that the system will engender modification of currently held views on the shipping of commodities presently thought best shipped in a frozen state. Continued exploitation of the invention as it finds increasing favor in the shipping field will reveal facets not categorically enumerated herein, but such further benefits, as well as variations in the mode of construction and operation of the system, are obtainable without departing from the spirit and scope of the invention.

What is claimed is:

1. A temperature-controlled system for the transportation of perishable commodities, comprising: a transportable insulated container having a floor, a roof and walls defining a lading space for such commodities and further including a cooling compartment separate from said space and adapted to contain a constantly effective cooling medium; means for effecting heat-transfer communication between the space and the compartment for extracting heat from said space; a constantly operating heater externally of the space; a main heater line within the lading space and connected to the heater for adding heat to said space at times during extraction of heat from said space by the aforesaid cooling medium; a heat by-pass line externally of said space and connected to the main heater line; and a heat flow control device having first and second positions respectively incurring main line heating and by-pass line cooling for adding heat to said space as aforesaid or by-pass line heating and main line cooling for discontinuing the addition of heat to said space, said device including a temperature-responsive device operative in response to rise and fall of container temperature relative to a predetermined value to respectively achieve the second and first positions of said device for regulating the addition of heat to said space; and means responsive to main line temperature for varying the capacity of said heat transfer communication means in inverse proportion to increase in container temperature as affected by heat added by the heater line.

2. A temperature-controlled system for the transportation of perishable commodities, comprising: a transportable insulated container having a floor, a roof and walls defining a lading space for such commodities and further including a partition affording a cooling compartment separate from said space and adapted to contain water ice as a constantly effective cooling medium, said partition having an opening therein for effecting heat-transfer communication between said compartment and said space for extracting heat from said space; adjustable closure means arranged to selectively vary the size of said opening; a constantly operating liquid heater externally of the container and having a liquid inlet and a liquid outlet and including a regulator for selectively increasing and decreasing the heater output; a main liquid line lying along the floor within the lading space and exclusively of the cooling compartment and connected as opposite ends respectively to the inlet and outlet for adding heat to said space at times during extraction of heat from said space by the aforesaid cooling medium; a liquid by-pass line external to both the lading space and the cooling compartment and cross-connecting the inlet and outlet; a flow control valve having a first position incurring heating of the main line for adding heat to said space as aforesaid and cooling of the by-pass line for discontinuing the addition of heat to said space and a

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second position incurring cooling of the main line and heating of the by-pass line and further having an intermediate status effecting throttling of flow through the main line to apportion flow through both lines simultaneously, said valve including a temperature-responsive device operative in response to rise and fall of lading space temperature relative to a predetermined value to respectively achieve the second and first valve positions and operative in response to intermediate temperatures in the lading space to achieve said intermediate status of said valve and accordingly to balance the addition of heat to said space against the extraction of heat from said space in accord with and to maintain said predetermined temperature value; a heater regulator actuator operatively connected to the heater regulator and including a temperature-responsive device effective in response to heating and cooling of the by-pass line to adjust the heater regulator for respectively decreasing and increasing the heater output; and a closure means actuator connected to and for operating the aforesaid closure means and including a temperature-responsive device effective in response to rise and fall of main line temperature to respectively close and open said closure means and responsive to intermediate main line temperatures to adjust the closure means to restrict said partition opening whereby to regulate heat extraction in proportion to heat addition.

3. A temperature-controlled system for the transportation of perishable commodities, comprising: a transportable insulated container having a floor, a roof and walls defining a lading space for such commodities and further including a cooling compartment separate from said space and adapted to contain water ice as a constantly effective cooling medium; means for effecting heat-transfer communication between the space and the compartment for extracting heat from said space; a constantly operating heater externally of the space; a main heater line within the lading space and connected to the heater for adding heat to said space at times during extraction of heat from said space by the aforesaid cooling medium; a heat by-pass line externally of said space and connected to the main heater line; and a heat flow control device having first and second positions respectively incurring main line heating and by-pass line cooling or by-pass line heating and main line cooling and an intermediate status apportioning heat to both lines for discontinuing the addition of heat to said space, said device including a temperature-responsive device operative in response to rise and fall of container temperature relative to a predetermined value to respectively achieve the second and first positions of said device and responsive to intermediate container temperatures to achieve said intermediate status of said flow control device; and means responsive to main line heating and cooling for respectively cutting off and establishing said heat-transfer communication means and responsive to intermediate main line temperatures to restrict said heat transfer communication means.

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