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REFRIGERATING APPARATUS

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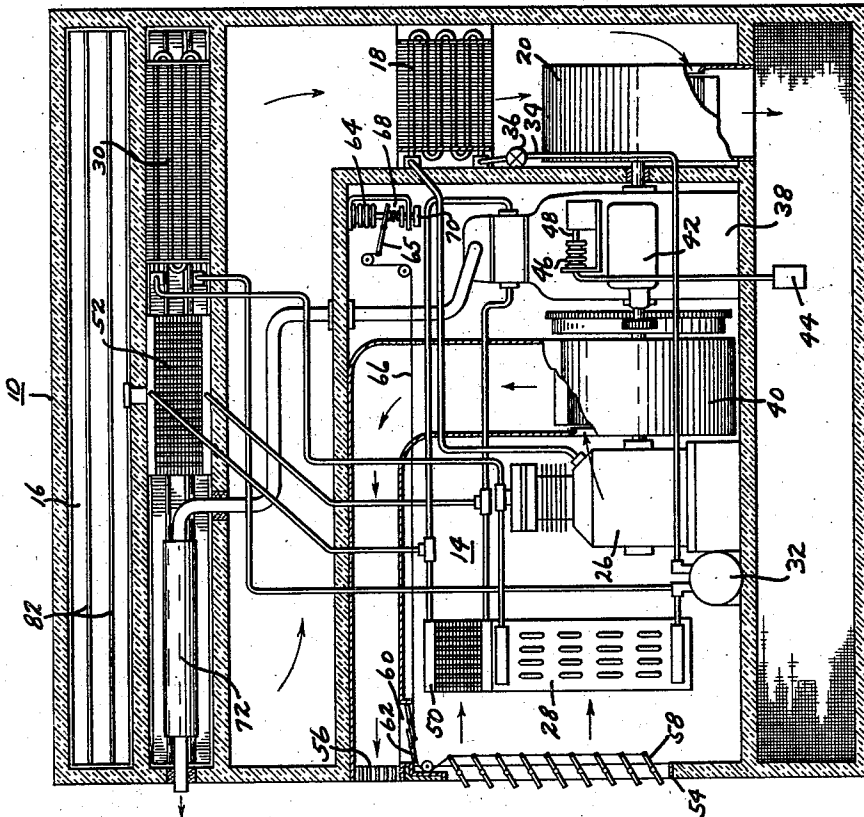


Fig. 1

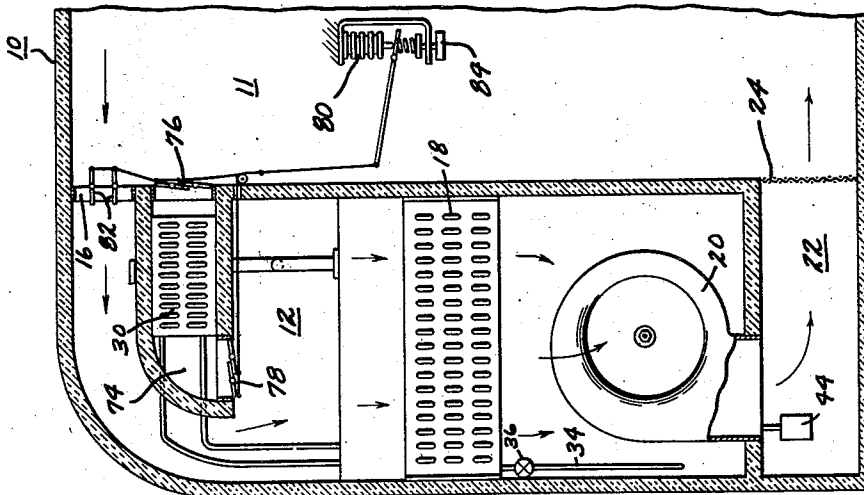


Fig. 2

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REFRIGERATING APPARATUS

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This invention relates to refrigerating apparatus and particularly to a refrigerating system for use on a railway car and for similar installations.

One object of this invention is to provide a compact system which requires a minimum amount of attention from time to time.

Another object of this invention is to provide a refrigerating system which is capable of maintaining the temperature within the car within a narrow temperature range.

Still another object of this invention is to provide a system which does not excessively dry the air.

Another object is to provide a system in which the waste heat from the refrigerating system may be utilized in tempering the air for the car.

A further object of this invention is to provide a refrigerating system which is flexible in operation but which does not employ any complicated electrical controls or complicated valve mechanisms.

A further object of this invention is to provide improved means for controlling the temperature within the machinery compartment.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawing, wherein a preferred form of the present invention is clearly shown.

In the drawing:

Fig. 1 is a sectional elevational view showing the arrangement of the refrigerating apparatus within the air conditioning compartment; and

Fig. 2 is a sectional view taken at right angles to the view shown in Fig. 1.

In designing a refrigerating system for use on railway cars, it is important to provide a refrigerating system which requires a minimum amount of attention since no one is in regular attendance and the system is required to operate for long periods of time without any special servicing. Refrigerating systems of the type disclosed herein are likewise suitable for use in establishments where service facilities are meager and the available service men are not sufficiently trained to service complicated systems.

For purposes of illustration, I have shown a refrigerating system embodying features of my invention installed in a railway car 10 having an air conditioning compartment 12 located at the one end of the car. As shown in Fig. 1, a machinery compartment 14 has been provided within the air conditioning compartment. This machinery compartment is completely sealed off from the rest of the air conditioning compartment

so as to prevent the escape of any oil or gas fumes from the machinery compartment into the main air circulating system.

Air from the storage compartment 11 enters the air conditioning compartment through the opening 16 adjacent the top of the car and flows in the direction of the arrows as indicated in Fig. 2. After entering the main air conditioning compartment 12, the air circulates in thermal exchange relationship with the refrigerant evaporator 18 and is then picked up by the blower 20 which discharges the air into plenum chamber 22 from which the air returns to the storage compartment 11 through the discharge opening 24 adjacent the bottom of the car. While I have shown the intake opening at the top of the car and the discharge opening at the bottom of the car, it is to be understood that this arrangement is shown primarily for purposes of illustration and that these openings may be arranged in any conventional manner so as to meet the particular needs in each installation.

The refrigerating system comprises the evaporator 18, the compressor 26, a main condenser 28, an auxiliary condenser 30 and a liquid refrigerant receiver 32. The compressor 26 withdraws the vaporized refrigerant from the evaporator 18 and discharges the compressed refrigerant vapor to the condensers 28 and 30 which are arranged in parallel for a purpose to be described hereinafter, and the liquid refrigerant condensed by these condensers flows into the liquid receiver 32 from which the liquid refrigerant flows through the pipe 34 into the evaporator 18. The usual form of control valve 36 is provided for controlling the flow of refrigerant to the evaporator. The compressor 26 is driven by means of a Diesel engine 38 or its equivalent which also operates the blower 20 as well as the blower 40 which circulates outside air through the machinery compartment 14. The Diesel engine 38 is provided with a conventional starter 42 which may be manually energized since in the refrigerating system shown the engine is normally operated continuously without automatic on and off cycling. While the refrigeration may be controlled by automatically starting and stopping the engine, I prefer to operate the engine continuously and vary its speed.

In order to control the speed of the engine so as to vary the amount of refrigeration available, I have provided a thermostat 44 which, for purposes of illustration, has been shown as being placed in the discharge air stream. The thermostat 44 is charged with a volatile fluid which

causes expansion and contraction of the bellows 46 which in turn operates the throttle 48 of the Diesel engine. The cooling water for the Diesel engine is cooled in the radiators 50 and 52 which are arranged in parallel for a purpose to be explained hereinafter. In order to cool the condenser 28, the radiator 50 and the rest of the apparatus within the machinery compartment 14, outside air is introduced through the opening 54 in the side wall of the car and is discharged by the blower 40 through an outlet 56 also arranged in the side wall of the car. For purposes of illustration, the opening 56 has been shown as being located directly above the air intake opening 54; however, this opening may be arranged to discharge the air underneath the car, at the top of the car or at the side opposite the opening 54.

In order to control the amount of cooling air circulated through the engine compartment 14, a damper 58 has been provided for the opening 54 and a by-pass opening 60 has been provided whereby a portion or all of the air circulated by the blower 40 may be recirculated through the machinery compartment so as to conserve on the amount of heat dissipated directly to the exterior of the car. A damper 62 has been provided in the opening 60 for controlling the by-passing or recirculation of the air. The arrangement of the dampers 58 and 62 is such that the damper 62 is fully closed when the damper 58 is open and the damper 58 is fully closed when the damper 62 is fully open. Both dampers are operated in unison by means of the thermostatic element 64 which, for purposes of illustration has been shown mounted directly within the machinery compartment 14. The thermostatic element 64 could be arranged directly within the compartment 11 or in any one of the air streams depending upon the particular conditions which it is desired to control. If desired, the thermostat 64 could be replaced by means of a control responsive to the refrigerant pressure. The thermostat 64 operates the pivoted lever 66 which has the flexible damper cable 68 connected to it at the one end. The thermostat 64 operates against the spring 68, the tension of which may be adjusted by the thumb screw 70.

As shown in the drawings, the condenser 30, the engine radiator 52 and the engine muffler 72 are all disposed in a heating chamber 74 provided in the upper portion of the air conditioning compartment 12. When cooling alone is desired, the heating compartment 74 is completely closed off from the compartments 11 and 12 by means of the dampers 76 and 78 which are arranged at the inlet and outlet openings respectively of the heating compartment 74. In order to control the flow of air through the heating compartment 74, I have provided a thermostat 80 within the compartment 11 which controls the dampers 76 and 78 as well as a damper 82 arranged in the opening 16. As shown in Fig. 2, the dampers 76 and 78 are closed when the damper 82 is open, and as the dampers 76 and 78 are opened the damper 82 moves to the closed position. Each of the dampers shown in the system is biased to the position in which the damper is shown in the drawing. The thermostat 80 is adjusted by means of the adjusting screw 84 so as to operate the dampers to cause circulation of air over the heating elements in the event that it is necessary to heat the air in the car.

Attention is called to the fact that with the arrangement shown, the Diesel engine is intended

to operate at all times. It is also intended to have all of the air circulated by the blower 20 to pass over the evaporator 18 at all times regardless of the temperature within the space 11.

Inasmuch as the Diesel engine never stops, a certain amount of refrigeration will at all times be supplied by the evaporator 18. However, at such times when the air from the compartment 11 circulates through the heating compartment 74 before circulating over the evaporator 18, the effect will be to heat the air for the compartment rather than cooling the air for the compartment since heat dissipated by the engine 38 is added to the air.

It will be observed that the condenser 30 is mounted above the condenser 28 and that the condensers are arranged in parallel without any control valves for controlling the flow to the condensers. By virtue of the arrangement shown, either or both of the condensers may be used for condensing refrigerant depending upon the temperature of the air flowing over the respective condensers. When no fresh air is introduced into the compartment 14 the air therein will become too hot for cooling purposes. Considering, for example, the condition under which the damper 58 is fully closed and the dampers 76 and 78 are fully opened, the condenser 30 will serve to condense the major portion of the refrigerant where- by the heat absorbed by the evaporator 18 will be dumped back into the air stream flowing over the evaporator 18. By virtue of the fact that the radiator 52 is disposed above the radiator 50 a very similar effect is obtained as with the evaporators in that the radiator 52 will dissipate most, if not all, of the heat given off by the engine, at all times when the relatively cool air from the compartment 11 circulates over the radiator 52 and no outside air is circulated over the radiator 28.

The system described hereinabove is especially suitable for use in refrigerated freight cars since the arrangement of the elements is such that a minimum amount of moisture is removed from the air. During the heating period, for example, the air is first circulated through the heating compartment and is thereafter circulated over the evaporator so as to give up a portion of its heat. However, the temperature of the air passing over the evaporator is sufficiently high to prevent any great amount of condensation forming on the evaporator coils during the time heating is required. In installations in which the removal of moisture would be desirable, the air would first be circulated over the evaporator and then over the condenser.

For purposes of illustration, the control instruments have all been shown as being responsive to the dry bulb temperature. However, it is to be understood that other types of controls such as wet bulb instruments, humidostats, effective temperature responsive instruments, and the like may be substituted for the dry bulb instruments, if desired.

While I have shown the evaporator 18 mounted in the air passage directly above the fan 20, it is apparent that the evaporator might also be located adjacent the outlet from the compartment 22. No attempt has been made in this application to show any ventilating means for introducing fresh air into the conditioned space. However, any of the well-known ventilating means may be used in combination with the system described hereinabove.

While the form of embodiment of the invention

as herein disclosed, constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What is claimed is as follows:

1. In a refrigerating system, an evaporator, a plurality of condensers arranged in parallel, a compressor, refrigerant flow connections between said evaporator, compressor and condensers, means for circulating a stream of air to be conditioned in thermal exchange relationship with one of said condensers and thereafter with said evaporator, means for circulating outside air over a second of said condensers, and temperature responsive means for controlling the flow of outside air over said second condenser.

2. In a refrigerating system, an evaporator, a plurality of condensers arranged in parallel, a compressor, refrigerant flow connections between said evaporator, compressor and condensers, means for circulating a stream of air to be conditioned in thermal exchange relationship with one of said condensers and thereafter with said evaporator, means for circulating outside air over a second of said condensers, and temperature responsive means for controlling the flow of outside air over said second condenser, said last named means being responsive to the temperature of the air surrounding said second condenser.

3. In a refrigerating system, an evaporator, a plurality of condensers, a compressor, refrigerant flow connections between said evaporator, compressor and condensers, means for circulating a stream of air to be conditioned in thermal exchange relationship with one of said condensers thereafter with said evaporator, and means for circulating outside air over a second of said condensers and means for varying the amount of air flowing over one of said condensers.

4. In a refrigerating system, an evaporator, a plurality of condensers, a compressor, refrigerant flow connections between said evaporator, compressor and condensers, means for circulating a stream of air to be conditioned in thermal exchange relationship with one of said condensers and thereafter with said evaporator, means for circulating outside air over a second of said condensers, and means for varying the capacity of one of said condensers.

5. In combination, an evaporator, a compressor, a condenser, refrigerant flow connections between said evaporator, compressor and condenser, an internal combustion engine for operating said compressor, means for circulating a stream of air to be conditioned in thermal exchange with said evaporator, means operated by said engine for circulating a stream of outside air in thermal exchange with said condenser and said internal combustion engine, means for discharging waste engine heat into said first named stream of air while said first named stream of air is being cooled by said evaporator, means influenced by the temperature of the conditioned air controlling the speed of said engine, and temperature responsive means for controlling the flow of air over said condenser.

6. Gas conditioning apparatus comprising in combination, means forming a gas conditioning chamber, an evaporator in said chamber, a heat dissipator in said chamber, means for circulating a stream of gas through said chamber, means for by-passing said gas around said heat dissipator, means forming a refrigerant liquefying chamber, refrigerant liquefying apparatus including a compressor and an internal combustion

engine in said last named chamber for supplying liquid refrigerant to said evaporator, means for discharging heat from said refrigerant liquefying apparatus to said heat dissipator, means for circulating a cooling fluid in thermal exchange with said refrigerant liquefying apparatus, means for varying the speed of said engine, and means for varying the amount of heat absorbed by said last named fluid.

7. In combination, means forming a gas conditioning chamber, an evaporator in said chamber, a heat dissipator in said chamber, means for circulating gas over said heat dissipator and thereafter over said evaporator, means for by-passing said gas around said heat dissipator, means forming a refrigerant liquefying chamber, refrigerant liquefying apparatus in said last named chamber for supplying liquid refrigerant to said evaporator, means for discharging heat from said refrigerant liquefying apparatus to said heat dissipator, means for circulating a cooling fluid in thermal exchange with said refrigerant liquefying apparatus, means for controlling the operation of said liquefying apparatus, and means for controlling the amount of heat absorbed by said last named fluid, said refrigerant liquefying apparatus comprising a compressor and an internal combustion engine for operating said compressor.

8. In combination, means forming a gas conditioning chamber, an evaporator in said chamber, a heat dissipator in said chamber, means for circulating a stream of gas through said chamber, means for by-passing said gas around said heat dissipator, means forming a refrigerant liquefying chamber, refrigerant liquefying apparatus in said last named chamber for supplying liquid refrigerant to said evaporator, means for discharging heat from said refrigerant liquefying apparatus to said heat dissipator, means for circulating a cooling fluid in thermal exchange with said refrigerant liquefying apparatus, means controlling the operation of said apparatus, and means for controlling the amount of heat absorbed by said last named fluid.

9. Air conditioning apparatus for an enclosure comprising in combination, an air flow passage, first and second heat exchangers arranged in said passage, means for circulating air to be conditioned over said first heat exchanger and thereafter over said second heat exchanger, means for supplying liquid refrigerant to the second of said heat exchangers, means for withdrawing refrigerant vaporized in said second heat exchanger and discharging the same under pressure into the first of said heat exchangers, means responsive to the temperature within said enclosure for by-passing the air around one of said heat exchangers, and means controlling the amount of heat discharged by said first heat exchanger.

10. In combination, an evaporator, refrigerant liquefying apparatus for supplying liquid refrigerant to said evaporator comprising a compressor, a condenser and an internal combustion engine for operating said compressor, means forming an air duct within which said evaporator is located, means enclosing said refrigerant liquefying apparatus, liquid circulating means for transferring heat generated by said apparatus out of said enclosing means and into said air duct, means for circulating air to be conditioned through said air duct, and means responsive to a predetermined low temperature for increasing the amount of liquid refrigerant supplied to said evaporator.

11. In combination, an evaporator, refrigerant liquefying apparatus for supplying liquid refrigerant to said evaporator comprising a compressor, a condenser and an internal combustion engine for operating said compressor, means forming an air duct within which said evaporator is located, means enclosing said refrigerant liquefying apparatus, liquid circulating means for transferring heat generated by said apparatus out of said enclosing means and into said air duct, means for circulating air to be conditioned through said air duct, means responsive to a predetermined low temperature for increasing the amount of liquid refrigerant supplied to said evaporator, and means discharging heat generated by said apparatus into an outside air stream when the air to be conditioned does not require heating.

12. Air conditioning apparatus for a compartment to be cooled comprising in combination; an evaporator; means for circulating one stream of air for said compartment in thermal exchange with said evaporator; refrigerant liquefying apparatus for supplying liquid refrigerant to said evaporator; means for circulating a second stream of air in thermal exchange with said refrigerant liquefying apparatus; said refrigerant liquefying apparatus comprising means for circulating a heat transfer fluid in thermal exchange with said first and second streams of air and said liquefying apparatus for heating said first named stream of air before the air is cooled by said evaporator; means for controlling the flow of air over said liquefying apparatus; and temperature responsive means for controlling the operation of said refrigerant liquefying means.

13. In combination, a first heat exchanger

adapted to function as an evaporator for absorbing heat; a second heat exchanger adapted to function as a condenser for dissipating a portion of the heat absorbed by said first heat exchanger, a third heat exchanger adapted to function as a condenser for dissipating a portion of the heat absorbed by said first heat exchanger, a compressor for withdrawing refrigerant from said first heat exchanger and discharging said refrigerant into another of said heat exchangers, an internal combustion engine for energizing said compressor, means for flowing a medium to be conditioned in thermal exchange with said first and second named heat exchangers, means for circulating a stream of fluid in thermal exchange with said internal combustion engine and said third named heat exchanger, means for regulating the temperature of the fluid circulated in thermal exchange with said engine, and temperature responsive means for controlling the flow of fluid over said engine.

14. In combination, an evaporator, a compressor, a condenser, refrigerant flow connections between said evaporator, compressor and condenser, an internal combustion engine for operating said compressor, means for circulating a stream of air to be conditioned in thermal exchange with said evaporator, means for circulating a separate stream of outside air in thermal exchange with said condenser and said internal combustion engine, and liquid circulating means for discharging waste engine heat directly into said first named air stream before the air is circulated over said evaporator so as to modify the cooling and dehumidifying effect of said evaporator.

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