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[54] **AIR-CONDITIONING SYSTEM FOR VEHICLES, PARTICULARLY FOR RAIL CARS**

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[51] **Int. Cl.** **B60h 3/04**

[58] **Field of Search** 165/22, 50, 23, 42–44; 237/12.4

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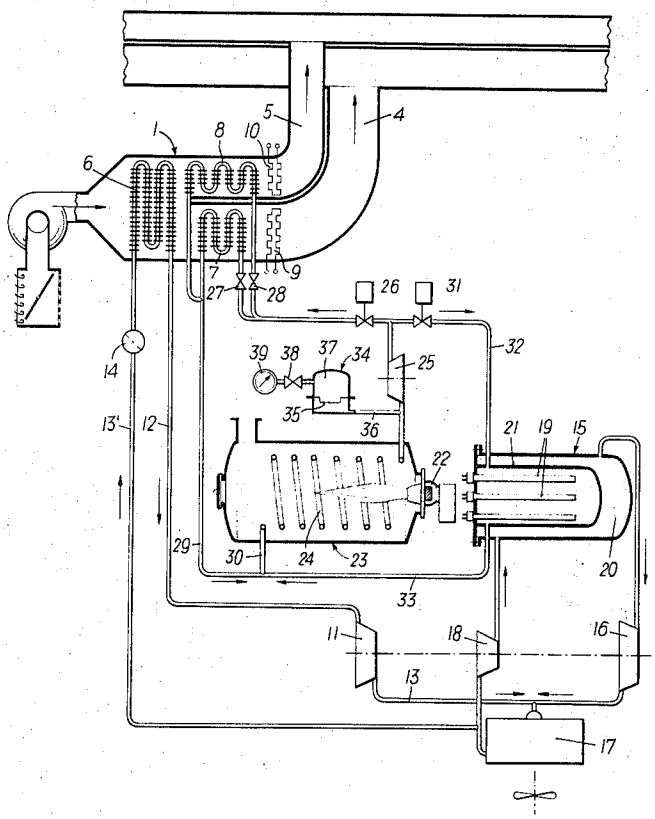
Primary Examiner—Charles Sukalo

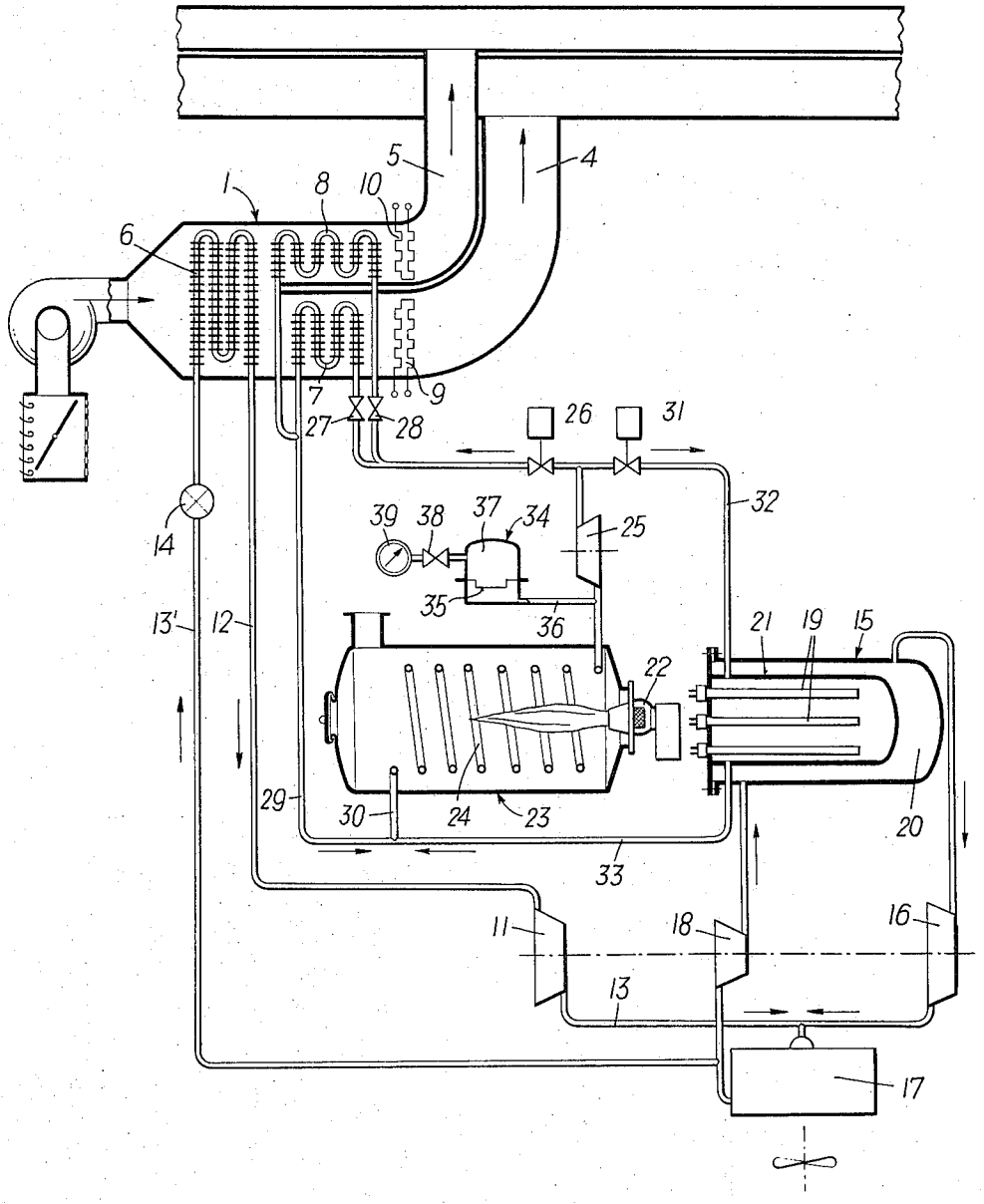
Attorney, Agent, or Firm—Watson, Cole, Grindle & Watson

[57] **ABSTRACT**

An air conditioning system for vehicles includes separate cooling and heating units, and a coolant vaporizer located in the ducts upstream of the air heater. Coolant circulation means circulates coolant between a cold-vapor boiler and a vaporizer means. Independent hot-water circulation means circulates hot water between a heat exchanger and the air heater and, since the water-containing chamber is connected in series to the hot water circulation means, the two units can be operated both separately and simultaneously. Such a system therefore permits pure cooling when the cooling unit alone is operated, permits pure heating when the heating unit alone is operated, and further permits a dehumidifying operation when both the heating and cooling units are operated.

4 Claims, 1 Drawing Figure




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AIR-CONDITIONING SYSTEM FOR VEHICLES, PARTICULARLY FOR RAIL CARS

The invention relates to an air-conditioning system for vehicles, particularly for rail cars, comprising an air-impinged air-conditioning assembly, the heating unit of which includes at least one air heater traversed by the heating water and connected to a water circuit heated by means of an oil burner.

An air-conditioning system of this type makes it possible for vehicles having no external power supply means to be adequately heated. This applies for example, to sleeping cars and other rail cars requiring appropriate preparations prior to their actual use if and when the need arises from the heating system to be already in operation during this preparatory work. The oil burner is used only until such time when an external power supply is available as for example, when the car is coupled to the train, when the oil burner is superseded by the conventional electric or steampowered air heater of the air-conditioning unit of the train as a means for heating the car.

A major drawback of conventional air-conditioning systems of the type hereabove described resides in the fact that it is impossible during the hot season for the car to be cooled when it stands detached from the train and/or parked on a siding. In such cases where for example, the train had for some time been exposed to sunshine, the temperature in the interior of the car rises to the discomfort of passengers until such time when it diminishes again after a few miles' travel as a result of cooling-air supplied by the air-conditioning unit.

It is the purpose of the present invention to provide an air-conditioning system of the type hereabove described which can be operated independently from any external power supply both as a heating and as a cooling means as required. According to the invention, the cooling unit of the air-conditioning system comprises in a manner known per se, a coolant vaporizer connected to a refrigeration circuit operated by means of an electrically heated cold-vapor boiler comprising an additional heater impinged upon by heating-water from the water circuit heated by means of the oil burner. The oil burner required for heating purposes anyway is thus used to advantage as a source of power for the cooling unit of the air-conditioning assembly so that at negligible expense both with regard to construction, space and weight, by nothing more than the extension of the existing piping, an air-conditioning assembly is obtained which is available under all operational conditions and ensures effective cooling of the car. In addition to straight cooling or heating, the system can also be used for mixed air-conditioning when both the air heater and the cold-vapor boiler are impinged upon by water heated by means of the oil burner. The well-known face that some heat is required also during the cooling period, namely either for dehumidification of air cooled down below the point of condensation by means of re-heating or in order to compensate for temperature variations in moderately cooled compartments caused by the steady flow of incoming and outgoing passengers.

According to a preferred embodiment of the invention, the additional heating unit comprises a water reservoir located in the coolant chamber of the cold-vapor boiler and preferably containing also the electric heater, such as heating rods. By means of a pipe provided on each side, the water reservoir is connected to

the sectors of the heating-water circuit located in front of and behind the oil burner. The result of this arrangement is an extremely simple and space-saving design of the cold-vapor boiler featuring two different heaters, the water contents of the water reservoir serving as a heat carrier for the heating of the coolant on both operational cycles. Likewise, the same design also permits of operating both heating units simultaneously in such cases where electric power is available.

According to a further embodiment of the invention, the oil burner in the hot-water circuit is followed by a valve assembly comprising for example, two solenoid valves by means of which the air heater(s) and/or the cold-vapor boiler can be impinged upon by hot water. This provides an opportunity for regulating the two branches of the hot-water circuit individually in such a manner that both the heating and the cooling effect of the airconditioning system with burner coperation can be well adapted to suit given operational requirements.

According to a further feature of the invention, thermal expansion in the hot-water circuit containing pressure water exclusively is compensated for by the provision of a pressure-equalizing reservoir connected with the hot-water circuit and comprising a membrane, one side of which is impinged upon by the heating water whereas the other side is exposed to the pressure of an equalizing chamber impinged upon by compressed air. In actual practice, maintenance of a pressure of approximately 85 psi in the equalizing chamber has proved most convenient.

Further details of the invention will become apparent from the following description of a preferred embodiment of the invention with reference to the accompanying drawing which schematically shows a twin-channel-type air-conditioning system according to the invention.

Reference numeral **1** designates an air-conditioning assembly impinged upon by means of a blower **2** by fresh air and/or circulating air, depending on the position of a butterfly valve **3** preceding the blower. Two air-carrying ducts **4** and **5** emerge from the said air-conditioning assembly, of which the first air duct **4** having a larger cross-section than the other serves in a manner known per se for the supply of a permanently available basic portion of tempered air to the passenger compartments which temperature is controlled centrally by means of an external thermostat not shown in the drawing, which detects external factors influencing the temperature prevailing inside the compartment and controls the air-conditioning assembly accordingly.

The second air duct **5** of a smaller cross-section than the first carries an additional air current which is preferably kept at a constant temperature level and can be associated with individual passenger compartments by means of controlled outlets not shown. It serves to compensate for temperature fluctuations due to the intermittently changing occupancy of the passenger compartments. The individual outlets of the additional duct are controlled by means of internal thermostats.

The air-conditioning assembly **1** comprises a cooling unit including the coiled pipes of a coolant vaporizer **6** and extending over the entire air-carrying cross-section of the air-conditioning assembly **1**. Further included is a heating unit comprising two air heaters **7** and **8** impinged upon by hot water, each of the said air heaters being located in one of the two ducts **4** and **5** respec-

tively, and two electric air heaters **9** and **10**, each of which is associated with one of the two ducts, respectively.

The coolant vaporizer **6** is connected to a coolant circuit of conventional design comprising a cold-vapor boiler **15** equipped with two heaters and including a coolant chamber **20**. The saturated coolant vapor produced by the cold-vapor boiler is expanded by means of an expander **16** until its pressure has attained liquefaction level and is then allowed to condense in a condenser **17** cooled by means of a blower, for example. A circulating pump **18** actuated by means of the expander **16** returns the condensed coolant to the boiler **15**. The expander **16** further actuates a compressor **11** drawing in coolant vapor from the vaporizer **6** through a pipe **12** and compressing the same until such time when its pressure has attained liquefaction level. This vapor is also delivered via a pipe **13** to the condenser **17** where it is liquefied. The coolant circuit of the vaporizer **6** is completed via a connecting pipe **13'** emerging from the condenser **17** enclosing a throttle valve **14**.

Of the two heaters provided for the evaporation of the coolant in the cold-vapor boiler **15**, one is formed by electric heater rods **19** located in a water reservoir **21** protruding into the coolant chamber **20** of the boiler. This electric heater requires the availability of electric power and can therefore, only be used while the train is in normal operation, or if there is a possibility of connecting the side-tracked car to a source of electric power.

In order for the cold-vapor boiler **15** to be heated even when power cannot be obtained from the outside, the water reservoir **21** is connected to the hot-water circuit delivering hot water also to the two air heaters **7** and **8**. This hot-water circuit comprises a heat exchanger **23** fired by an oil burner **22** with a coiled pipe **24** heated by means of the burner flame and connected with the circulating pump **25**. The circulating pump **25** delivers the water heated in the heat exchanger **23** on the one hand via a solenoid valve **26** followed by two parallel additional solenoid valves **27** and **28** to the two air heaters **7** and **8**, from where the water cooled in the air current is returned through a return pipe **29** to the inlet **30** of the heat exchanger **23**.

On the other hand, the delivery end of the circulating pump **25** communicates via a further solenoid valve **31** and a pipe **32** with the water reservoir **21** of the cold-vapor boiler **15**, from which a pipe **33** also leading back to the inlet **30** of the heat exchanger **23** emerges.

In the event of a failure of the circulating pump **25**, the oil burner **22** is switched off automatically so as to prevent excessive heat from developing in certain areas of the hot-water circuit.

Associated with the hot-water circuit is also a pressure-equalizing reservoir **34** for the purpose of compensating for thermal expansion in the hot-water circuit carrying pressure water only. For that purpose, the pressure-equalizing reservoir **34** comprises a membrane **35**, one side of which is impinged by hot water via a connecting line **36**, whereas its other side defines an equalizing chamber **37** wherein air pressure of approximately **85** psi is maintained. Besides, a pressure gauge **39** is connected with the equalizing chamber **37** via a valve **38**.

The operation of the air-conditioning system illustrated in and by the accompanying drawing is as follows: If an electric power connection is not available in the immediate vicinity of the car equipped with the air-conditioning system, it is impossible to start either the electric air heaters **9** and **10** exclusively used during normal railroad service, or the electric heater **19** of the cold-vapor boiler **15**. In order for the air-conditioning system to go into operation even in the absence of any external power supply, the oil burner **22** is fired and the circulating pump **25** switched on. If the air-conditioning system is to be operated for heating purposes only, it will be sufficient to open the solenoid valve **26** while the solenoid valve **31** controlling the delivery of hot water to the cold-vapor boiler **15** stays closed. Consequently, hot water will flow to the air heaters **7** and/or **8**, one of the two air heaters being switched off if and as required by closing one of the two valves **27, 28**. The return pipe **29** completes this heating circuit so as to produce a self-enclosed system.

On the other hand, for the straight cooling cycle the solenoid valve **26** stays closed and the entire amount of hot water flows through the open solenoid valve **31** into the water reservoir **21** of the cold-vapor boiler **15** where it cools down and returns through pipe **33** to the heat exchanger **23**. As during the straight heating cycle, a self-enclosed hot-water circuit is again produced which is now limited to the heating of the cold-vapor boiler **15**. The coolant evaporated in the boiler **15** thus supplies the power required for the operation of the cooling unit of the air-conditioning assembly.

For mixed air-conditioning requiring the availability both of cool air and warm air, the two solenoid valves **26** and **31** stay open, so that both the coolant vaporizer **6** and the two air heaters **7** and **8** are ready for operation. It is thus possible to operate the airconditioning assembly in the same manner as if the train were in normal operation.

I claim:

1. In an air conditioning system for vehicles, especially for rail cars, having an air conditioning assembly including air blower means and ducts conducting the air from said means to vehicle passenger compartments to be air conditioned, comprising in combination:

a heating unit comprising a heat exchanger, an oil burner for firing said heat exchanger, at least one air heater located in said ducts, hot water circulation means for circulating hot water between said heat exchanger and said air heater, a circulation pump in said circulation means;

a cooling unit comprising a cold-vapor boiler, a water-containing chamber located within a coolant-containing chamber, coolant vaporizer means in said ducts adjacent said air blower means and disposed upstream of said air heater, coolant circulation means for circulating coolant between said cold-vapor boiler and said vaporizer means, a first heater means for said cold-vapor boiler comprising electric heating elements located in said water-containing chamber, said water-containing chamber being connected in series to said hot-water circulation means thereby defining a second heater means for said cold-vapor boiler.

2. In the system according to claim **1** wherein said hot-water circulation means includes air inlet conduit on said heat exchanger, a virst conduit interconnecting said inlet conduit and said air heater, a second conduit interconnecting said heat exchanger and said air heater, said circulation pump being located on said sec-

ond conduit, a third conduit interconnecting said inlet conduit and said water-containing chamber, and a fourth conduit interconnecting said second conduit and said water-containing chamber.

3. In the system according to claim **2** wherein a first valve is located on said second conduit between said circulation pump and said air heater, and wherein a second valve is located on said fourth conduit.

4. In the system according to claim **1**, further comprising a pressure-equalizing reservoir connected to said second conduit, said reservoir having a diaphragm therein separating said reservoir and two chambers, one of said reservoir chambers communicating with said second conduit and the other of said reservoir chambers being operatively connected to a compressed air source thereby constituting an equalizing chamber.

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