# United States Patent [19]

**Engel**

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[54] **AIR CONDITIONER FOR RAILROAD VEHICLES**


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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** ..... **62/173**, 62/90

[51] **Int. Cl.** ..... **F25b 29/00**

[58] **Field of Search** ..... 62/90, 173



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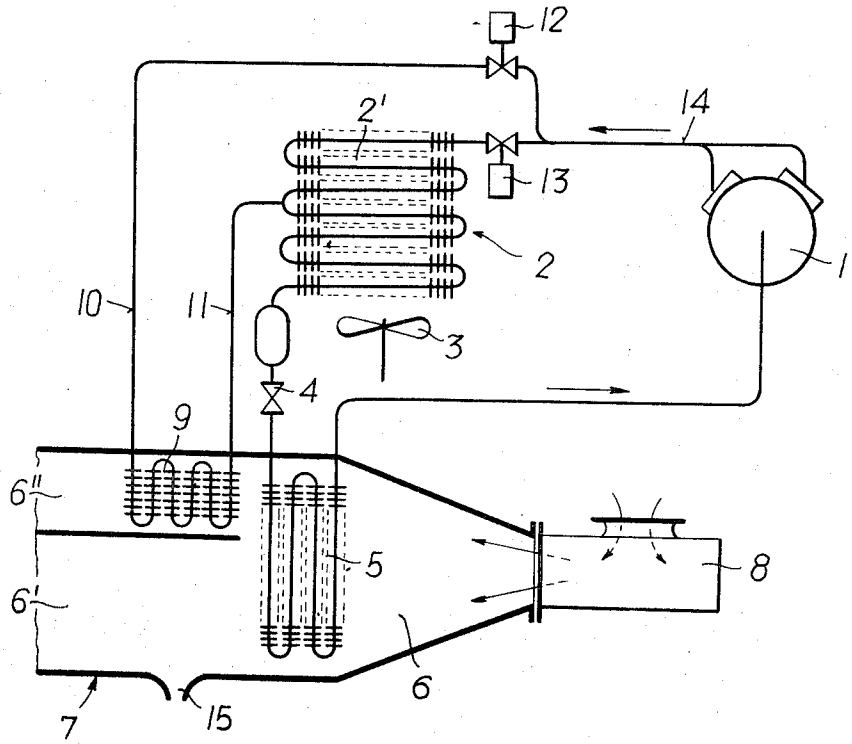
*Attorney*—Watson, Cole, Grindle & Watson



[57] **ABSTRACT**

An air conditioner for railroad vehicles, comprising an air-impinged heating and cooling assembly the cooling system of which includes a coolant evaporator arranged in the air current and a blower-cooled condenser, wherein an additional condenser serving as a booster heater is provided in the air current behind the evaporator in such a manner as to be insertable in the cooling system via a valve system, the additional condenser by-passing at least part of the condenser of the cooling system.


**1 Claim, 5 Drawing Figures**



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FIG. 1

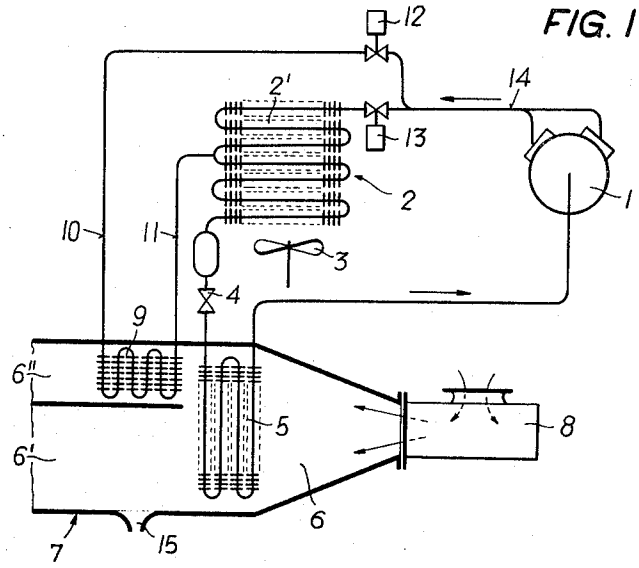



FIG. 2

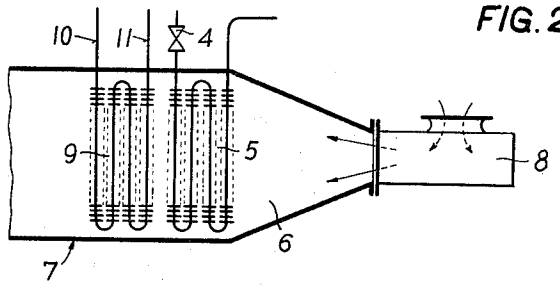



FIG. 3

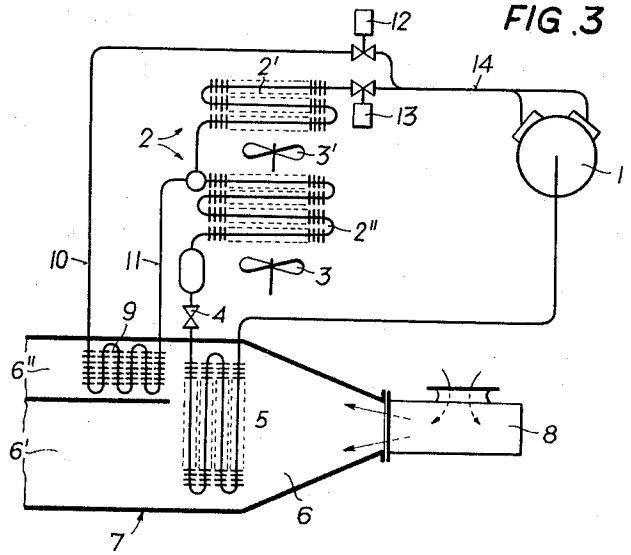


FIG. 4

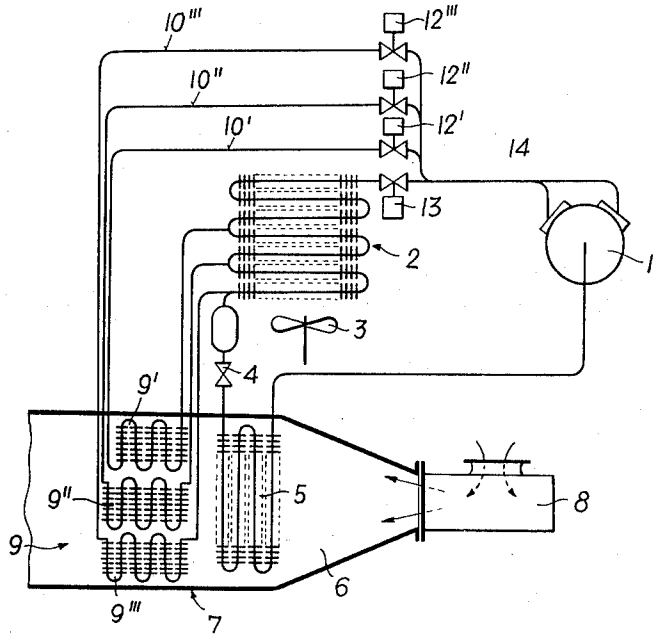
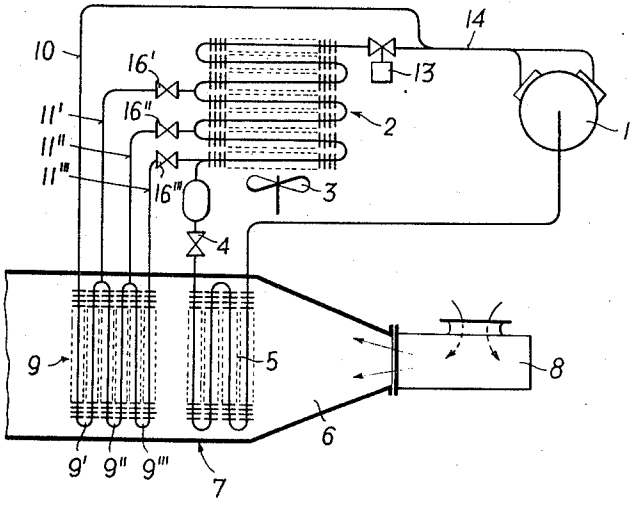

10'''
12'''
10''
12''
10'
12'
14
13
2
1
3
4
9'
9''
5
8
9
6
9'''
7

FIG. 5


14
10
16'
13
11'
16''
2
1
11''
11'''
16'''
3
4
9
5
8
6
9'
9''
9'''
7

# AIR CONDITIONER FOR RAILROAD VEHICLES

The invention relates to an air-conditioner for railroad vehicles comprising an air-impinged heating and cooling assembly the cooling system of which includes an evaporator located in the air current and a blower-cooled condenser, with a booster heater arranged in the air current behind the evaporator.

Similar air conditioners generally provide for the cooling of air down to a lower level than would be necessary for actual cooling requirements in order to ensure adequate dehumidization during the cooling operation, thereby descending below the point of condensation and allowing the air moisture to condensate before the air is supplied to the various compartments of the railroad vehicles. To meet actual cooling requirements, this higher cooling output should be compensated by appropriate reheating of the air by means of the booster heater. In conventional air conditioners an additional source of energy, such as steam or electric heaters, is used as a booster heater.

It is the purpose of the invention to provide an air conditioner for railroad vehicles, wherein the necessary dehumidization of air is obtained without additional energy consumption while taking full advantage of the space available. According to the invention, the air conditioner is provided with a booster heater designed as an additional condenser to be connected to the cooling system by means of a valve system if and when necessary, and by-passing at least part of the condenser of the cooling system, thus using at least part of the otherwise lost waste heat of the condenser for reheating the air that has been cooled down below the point of condensation. This use made of waste heat, as a result of which any additional energy supply to the booster heater may be dispensed with, is of particular importance for air conditioners of railroad vehicles because in the latter only relatively scant amounts of energy are available.

Furthermore, according to the invention the design of the heating and cooling assembly is simplified by the fact that no special connections for steam or electric heaters are required and the booster heater is directly incorporated in the existing cooling system.

Since it is possible according to the invention to by-pass certain sections of the condenser of the cooling system by means of the additional condenser, the air conditioner is readily adaptable to operating conditions ascribable to climatic factors such as outside temperature and air moisture. Experience has shown that during normal cooling at an average humidity level of the air, by-passing only part of the condenser associated with the cooling system is sufficient for reheating the air current cooled below the point of condensation as required, whereas in the event of air humidity being extremely high, the condenser may be by-passed completely, so as to make the entire waste heat of the coolant available in the area of the additional condenser. Accordingly, the air entering the heating and cooling assembly is first cooled as far as below the point of condesnation so that humidity is allowed to condensate, but it is again reheated in the area of the additional condenser as far as just below its inlet temperature. Therefore, in the latter case the heating and cooling assembly serves as an air dehumidizer exclusively.

According to another feature of the invention the additional condenser comprises at least two stages selectively connectable thereto by means of a valve system and by-passing different sections of the condenser of the cooling system. Consequently, the extent of waste heat recovery can be conveniently altered during the operation of the air conditioner to suit given requirements, with the additional possibility of reducing the output of the blower associated with the condenser of the cooling system as a function of the by-passed sections of this condenser, thereby saving additional energy.



Accordingly to another feature of the invention the additional condenser or one of its stages extends only over part of the air-current-carrying cross-section of the heating and cooling assembly. This design is suitable for example, for twin-duct-type air conditioners wherein the additional air condenser is associated with the one of the two ducts that carries the warmer air current.

According to a further feature of the invention, the valve system comprises thermostatically conrolled solenoid vales, one of which is series-connected to the condenser of the cooling system and at least another to the additional condenser or each of its stages. The solenoid valves are preferably controlled by means of an external sensor responsive to the outside temperature, air humitidty and possibly other factors of major importance for the air-conditioning of train compartments. With multi-stage additional condensers a separate external sensor is associated with each condenser stage or else an external sensor comprisng a number of control contacts equal to the number of stages of the additional condenser is provided.

Further details of the invention will become apparent from the following description of several embodiments of the invention with reference to the accompanying drawings in which

FIGS. 1 through 5 each are schematic views of embodiments of the invention limited to such sections of the air conditioner as are essential for the comprehension of the sceope of the present invention.

FIG. 1 shows the cooling system of the heating and cooling assembly of an air conditioner for railroad vehicles according to the invention. The cooling system comprises a coolant compressor 1, an air-cooled condenser 2 with the cooling blower 3, an expansion valve 4 and the coolant evaporator 5. The evaporator 5 is located in the air shaft 6 of the heating and cooling assembly 7 of the air conditioner. The air current passing therethrough is produced by a blower 8.

FIG. 1 represents a twin-duct air conditioner wherein the air shaft 6 is divided after the coolant evaporator 5 into two sub-ducts 6′ and 6″. In the sub-duct 6″ a booster heater is accommodated which according to the invention is designed as an additional condenser 9, selectively connectable via connecting pipes 10 and 11 to any of the coolant circits 1 through 5. For that purpose the connected via a solenoid valve 12 to the section 14 of the coolant pipe extending between the compressor 1 and the condenser 2. Another solenid valve 13 is series-connected to the condenser 2. With valve 12 closed and valve 13 open, the coolant flows through the condenser 2 exclusively. The air supplied by the blower 8 is cooled in the area of the evaorator 5 to a temperature usually below the point of condensation, so that the humidity of the air is allowed to condensate in the shaft 6 and to escape through an outlet 15 provided in the heating and cooling assembly 7. In order to increase the air temperature to the predetermined

level above the point of condensation required for sub-duct 6'', the two solenoid valves 12 and 13 are reversed, so that the additional condenser 9 by-passes section 2' of the condenser 2 and now serves as a vehicle for the coolant. As a result, that portion of the waste heat of the condenser 2 which corresponds to the by-passed condenser section 2 40 , is transferred from the additional condenser 9 to the air current passing through the sub-duct 6'' and the air temperature is increased to the required level. Consequently, no additional energy source is needed for reheating the cooled air.

The air conditioner shown in FIG. 2 differs from the design hereabove described insofar as the additional condenser 9 extends over the entire cross-section of the air shaft 6 and that the whole air current is reheated.

In the embodiment of the invention illustrated in FIG. 3 the condenser 2 of the coolant circuit comprises two separate sections 2' and 2'', each of which is associated with a separate blower 3 and 3', respectively. This arrangement offers the possibility of disconnecting the blower 3' of the by-passed condenser section 2' during the operational stages when the additional condenser 9 is connected, thereby saving energy. The remaining details of the cooling system are identical with those shown in FIG. 1.

FIG. 4 shows an air conditioner wherein the additional condenser 9 comprises three stages 9', 9'' and 9''', each of which by-passes different sections of the condenser 2 and is selectively connectable to the coolant pipe 14 via a connecting pipe 10', 10'' and 10''' respectively and a separate solenoid valve 12', 12'', and 12''', respectively. It is thus possible to vary the degree of reheating of the air current passing through the evaporator 5 as required.

Another variant of a multi-stage additional condenser according to the invention is shown in FIG. 5. The three stages 9', 9'', and 9''' of the additional condenser 9 are connected in series. On the one hand, the additional condenser 9 is directly connected to section 14 of the coolant pipe by means of a connecting pipe 10, and on the other hand, a connecting pipe 11' and 11'' respectively, branches off between consecutive condenser stages which similar to a connecting pipe 11''' beginning at the extremity of the third condenser stage 9''', leads via solenoid valves 16', 16'', and 16''' respectively to different junctions of the condenser 2. Again, there is the possibility of transferring the required portion of the waste heat of the condesner 2 by means of the stages of the additional condenser 9 to the air current flowing through the heating and cooling assembly.

We claim :

1. A two-channel air-conditioning system for railroad vehicles, comprising an air-impinged heating and cooling assembly, a first air-carrying channel extending from said heating and cooling assembly over a major portion of the air-impinged cross-section of said heating and cooling assembly, a second air-carrying channel extending from said heating and cooling assembly over the remaining air-carrying cross-section thereof, a coolant compressor, a condenser connected to said coolant compressor, a cooling-air blower for cooling said condenser, an expansion-type cutoff valve following said condenser, a coolant evaporator inserted between said expansion-type cutoff valve and said coolant compressor, said coolant evaporator being located within said cooling and heating assembly in the air current in front of said first and second channels, an additional condenser mounted in said second channel in the air current behind said coolant evaporator and bridging across at least part of said condenser, valve control means comprising a first solenoid valve inserted between said coolant compressor and said additional condenser, and a second solenoid valve inserted between said coolant compressor and said condenser.

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