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(54) AUXILIARY POWER UNIT HEATING SYSTEM

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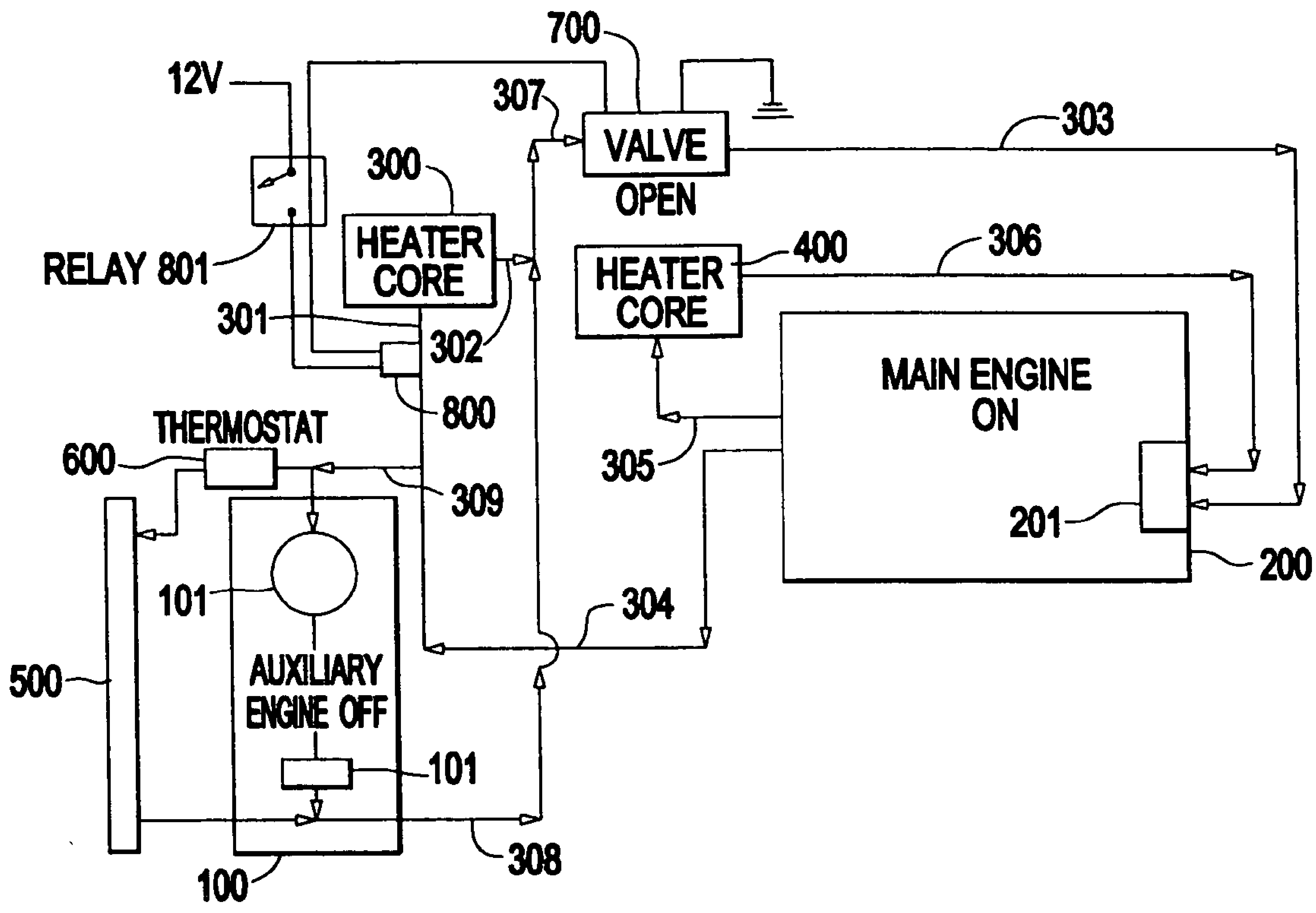
(57) **ABSTRACT**

An engine heating system for vehicles comprising an engine, a vehicle compartment heating system including fluid conduits extending from the engine to a heating unit and extending back to the engine, an auxiliary power unit on the vehicle including an auxiliary engine having a water pump driven by the auxiliary engine including fluid conduits extending from the auxiliary engine to a second heating unit located in a compartment of the vehicle and extending back to the auxiliary engine, fluid conduits extending from the engine to the second heating unit and extending back to the engine, a valve disposed in the fluid conduit between the second heating unit and the engine, the valve capable of receiving a signal, a temperature switch for detecting a coolant temperature, the temperature switch providing a signal to operate the valve, the valve allowing coolant circulation through the second heating unit to the main engine when the main engine is in operation or the coolant temperature is greater than a predetermined temperature, and the valve closed when the main engine is not in operation or the coolant temperature is below a predetermined temperature.



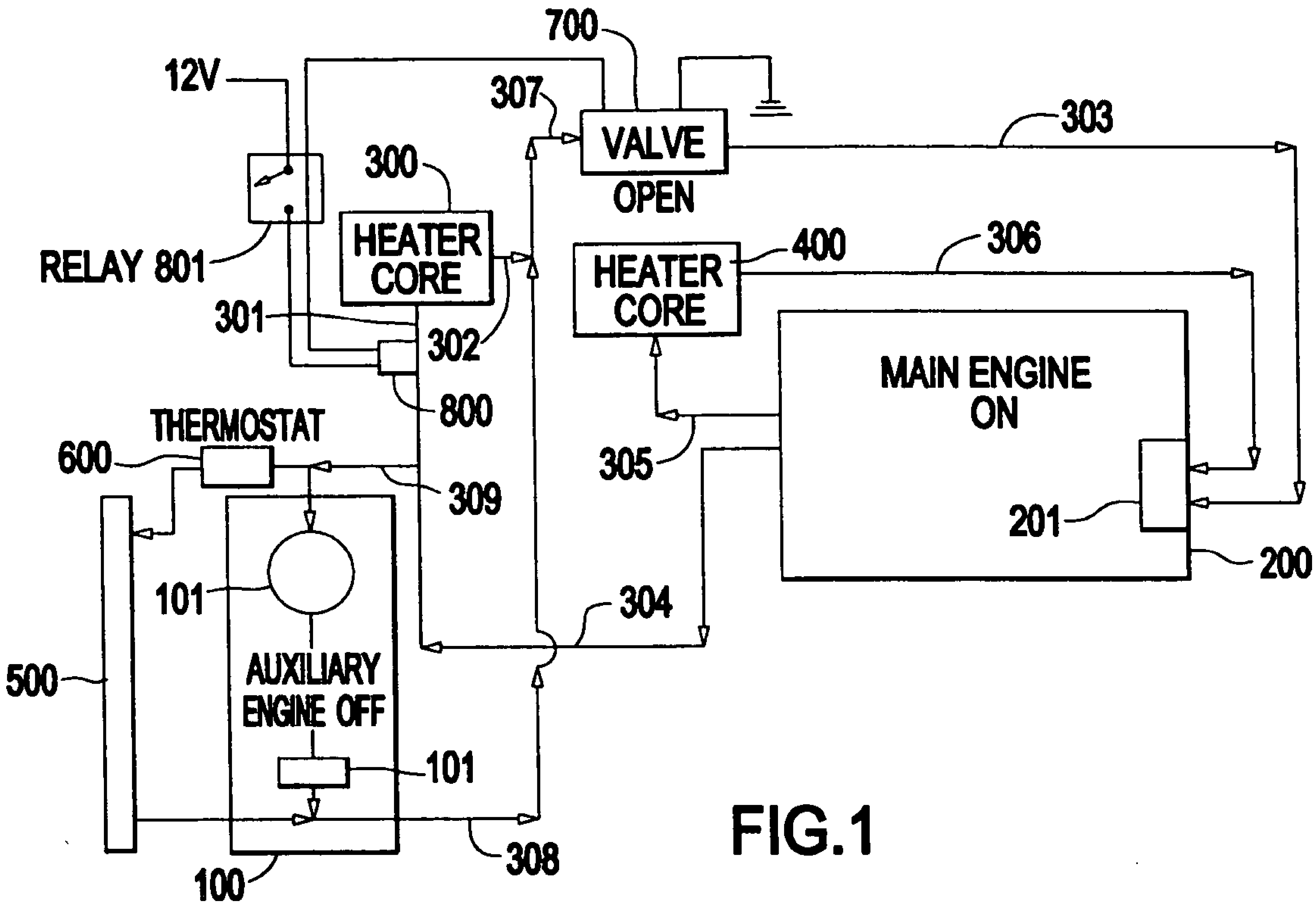

700
12V
307
VALVE
OPEN
303
300
HEATER CORE
RELAY 801
400
HEATER CORE
306
301
302
MAIN ENGINE ON
800
THERMOSTAT
600
309
305
201
200
101
304
500
AUXILIARY ENGINE OFF
101
308
100

FIG.1

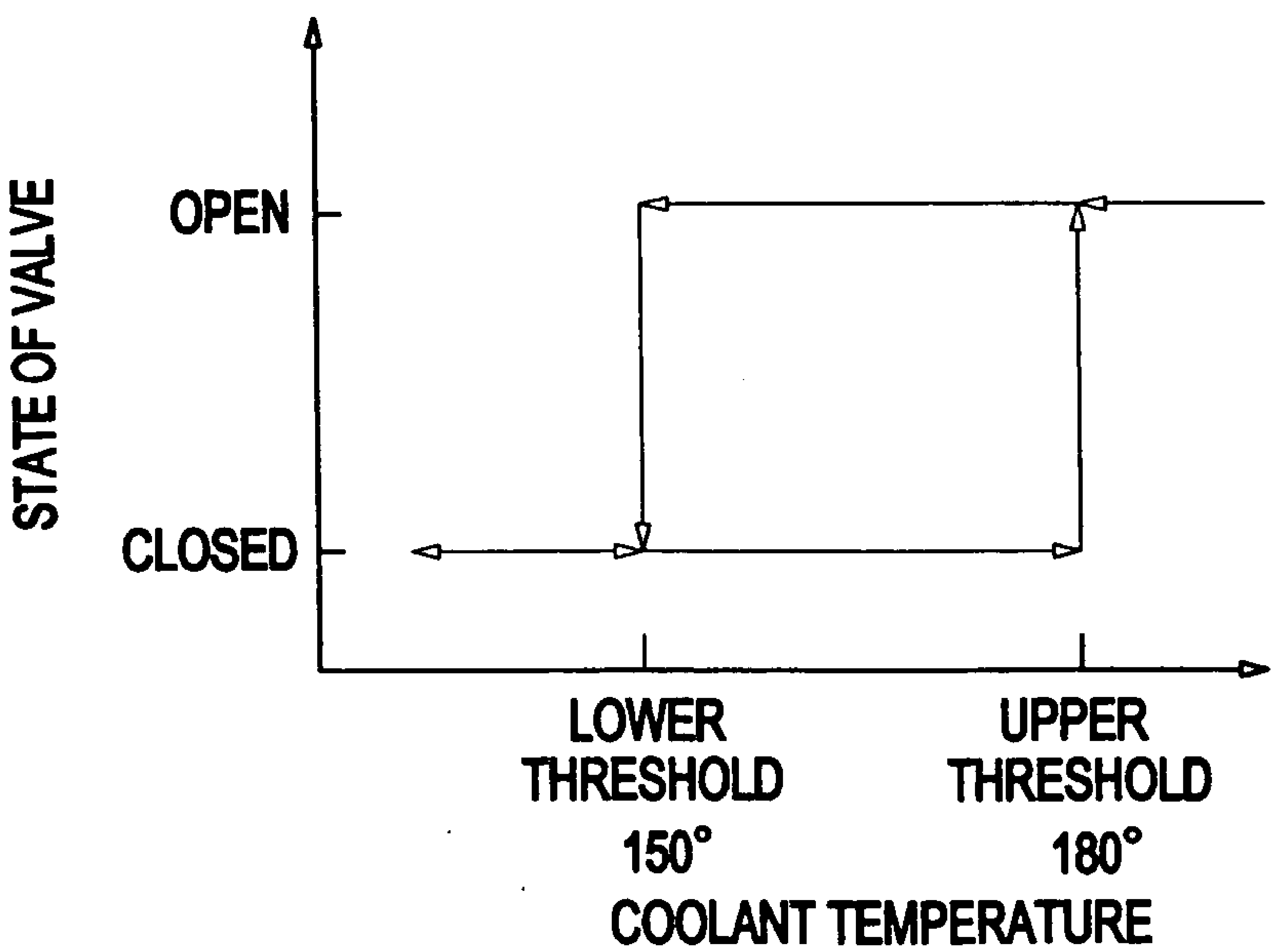

STATE OF VALVE
OPEN
CLOSED
LOWER THRESHOLD 150°
UPPER THRESHOLD 180°
COOLANT TEMPERATURE

FIG.2

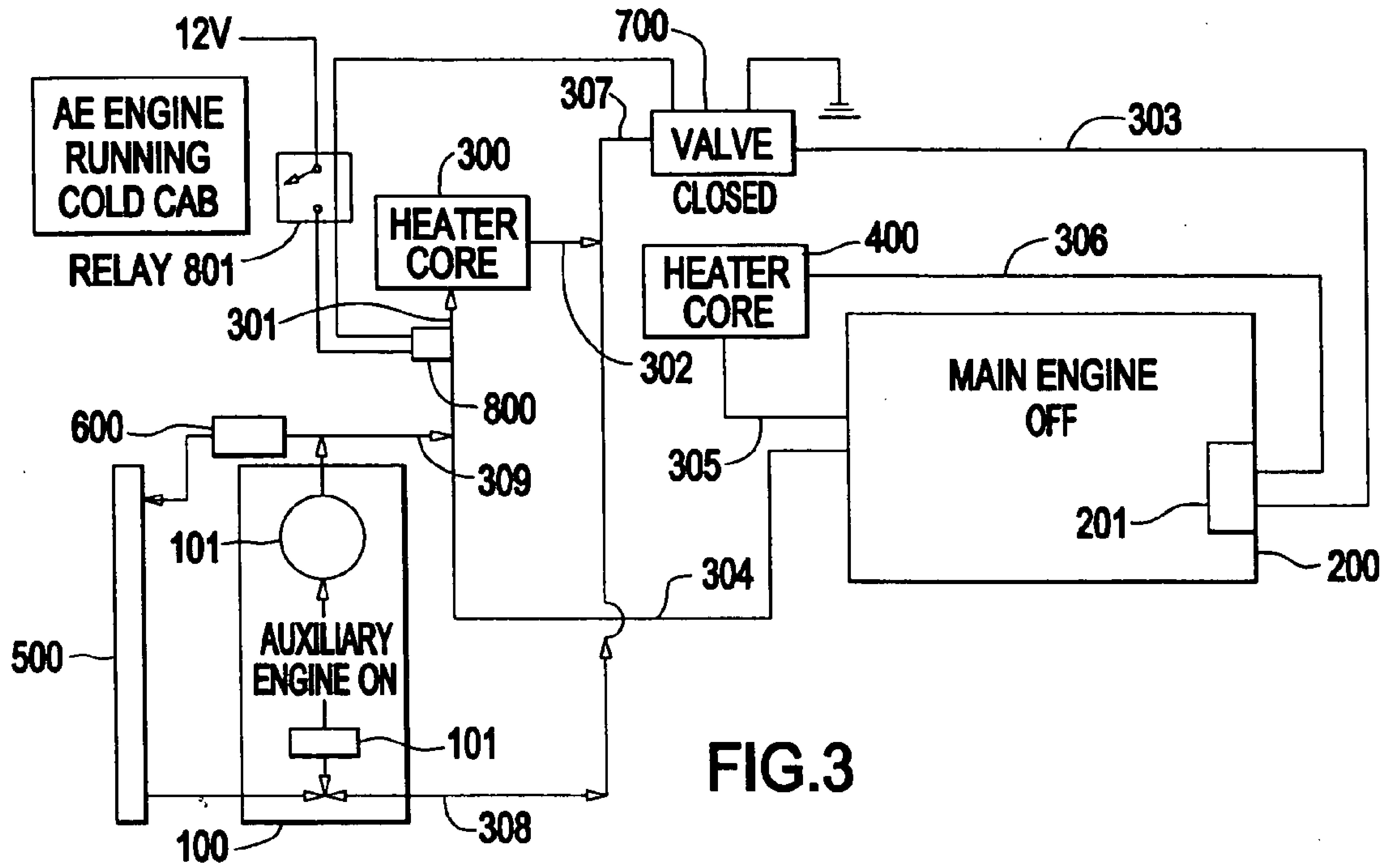

12V
AE ENGINE
RUNNING
COLD CAB
RELAY 801
700
307
VALVE
CLOSED
303
300
HEATER
CORE
400
HEATER
CORE
306
301
302
MAIN ENGINE
OFF
800
600
309
305
201
200
101
304
500
AUXILIARY
ENGINE ON
101
100
308

FIG.3

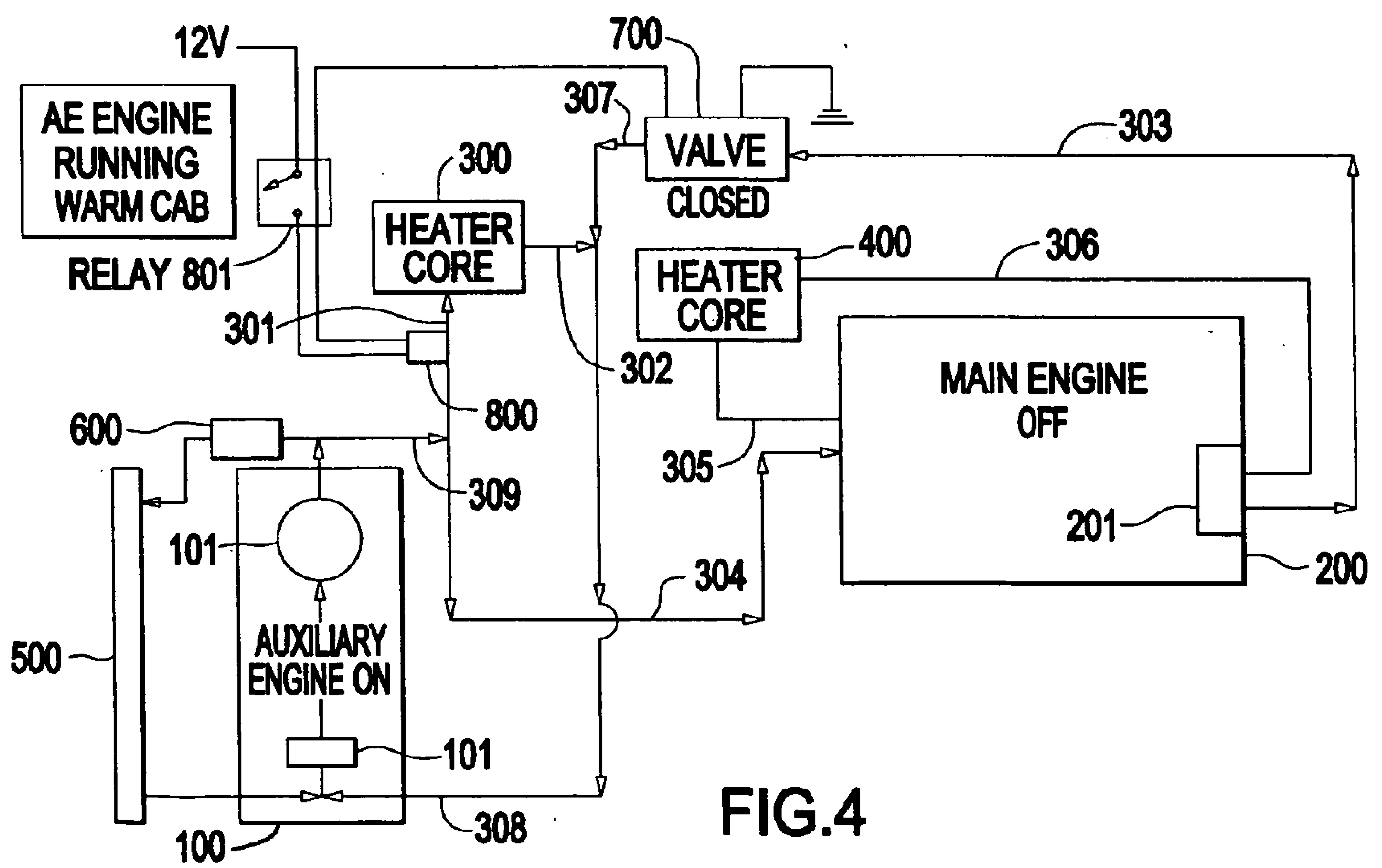

12V
AE ENGINE
RUNNING
WARM CAB
RELAY 801
700
307
VALVE
CLOSED
303
300
HEATER
CORE
400
HEATER
CORE
306
301
302
MAIN ENGINE
OFF
800
600
309
305
201
200
101
304
500
AUXILIARY
ENGINE ON
101
100
308

FIG.4

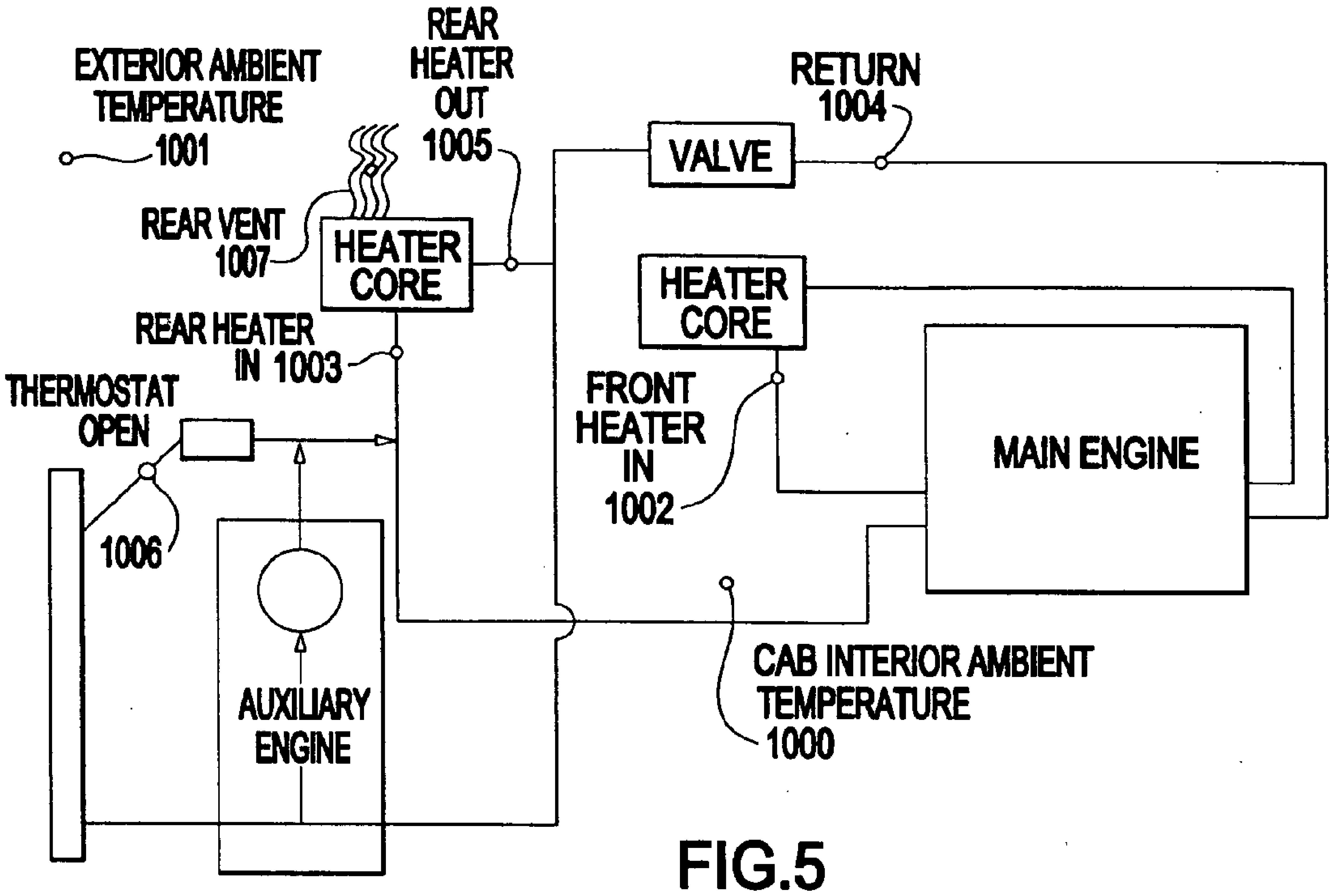

EXTERIOR AMBIENT TEMPERATURE
1001
REAR HEATER OUT 1005
RETURN 1004
VALVE
REAR VENT 1007
HEATER CORE
HEATER CORE
REAR HEATER IN 1003
THERMOSTAT OPEN
FRONT HEATER IN 1002
MAIN ENGINE
1006
AUXILIARY ENGINE
CAB INTERIOR AMBIENT TEMPERATURE
1000

FIG.5

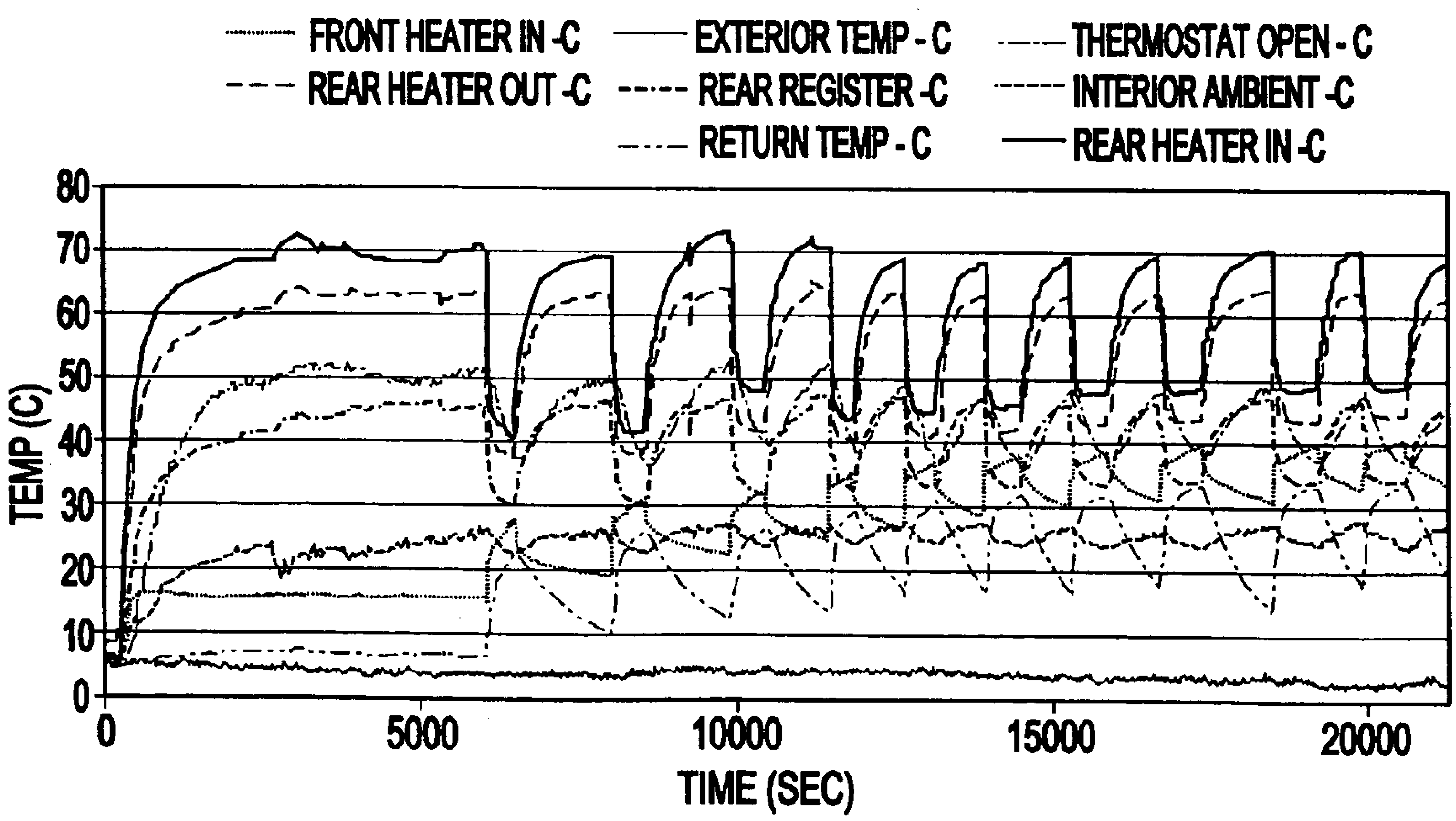

FRONT HEATER IN -C
EXTERIOR TEMP - C
THERMOSTAT OPEN - C
REAR HEATER OUT -C
REAR REGISTER -C
INTERIOR AMBIENT -C
RETURN TEMP - C
REAR HEATER IN -C
TEMP (C)
0
10
20
30
40
50
60
70
80
0
5000
10000
15000
20000
TIME (SEC)

FIG.6

	FLOW IN GALS/MIN		
NO VALVE	FLOW OUT AE	FLOW INTO REAR HEATER	FLOW INTO MAIN ENGINE
CLOSED	2.3	2.3	0
OPEN	2.3	1.5	1.25
CLOSED	1.5	1.5	0
OPEN	1.5	0.9	0.8
CLOSED	2	2	0
OPEN	2	1.2	1.08

FIG.7

AUXILIARY POWER UNIT HEATING SYSTEM

FIELD OF THE INVENTION

[0001] The invention relates to an auxiliary power unit heating system, and more particularly, to an auxiliary power unit heating system comprising a means for selectively isolating a cabin heating unit in the auxiliary power unit cooling system from a main engine coolant system while also providing heating capability for the main engine.

BACKGROUND OF THE INVENTION

[0002] Generally, large diesel engines are not shut down during cold weather conditions due to the difficulty in restarting. Diesel engines do not have the benefit of an electric spark to generate combustion and must rely on heat generated by compressing air to ignite fuel in the engine cylinders. In low temperature conditions (ambient temperatures below about 40° F.), two major factors contribute to the difficulty in starting a diesel engine. First, cold ambient air drawn into the engine must be increased in temperature sufficiently to cause combustion. Second, diesel fuel tends to exhibit poor viscous qualities at low temperatures, making engine starting difficult.

[0003] In cold weather, large engines are typically idled overnight to avoid the necessity to restart in the morning and to provide heat to the crew space. Diesel trucks that must operate in extremely cold environmental conditions must be run continuously, at high fuel cost, or, when shutdown, must be drained of engine coolant and provided supplemental electrical service and heating, also at high cost.

[0004] In warm weather, diesel engines typically idle to provide air conditioning and other services, including lighting, environmental heating and cooling, and electrical appliances.

[0005] Representative of the art is U.S. Pat. No. 4,756,359 to Greer (1988) which discloses a small lightweight auxiliary power plant including an engine, electrical alternator, water pump, air conditioning compressor and a heat exchanger is mounted at a convenient location on the tractor of a truck or other large vehicle. The main engine of the truck operates the existing truck air conditioning and heating system in a normal manner when the main engine is running. When the main engine of the truck is not operating and the smaller engine of the auxiliary power plant is operating, the truck air conditioning and heating system is operated by the auxiliary power plant. The heat exchanger of the auxiliary power plant then utilizes the heat of exhaust gases generated by the auxiliary power plant engine to warm the truck engine during the time it is not operating so that easy starting of the truck engine is made possible even in very cold weather. The exhaust gases from the auxiliary engine are also utilized to heat the lubricating oil of the main engine. When desired, an external load is applied to the crank shaft of the auxiliary engine to increase the heat output generated by the auxiliary engine.

[0006] What is needed is an auxiliary power unit heating system, and more particularly, an auxiliary power unit heating system comprising a means for selectively isolating a cabin heating unit in the auxiliary power unit heating system from a main engine coolant system while also providing heating capability for the main engine. The present invention meets this need.

SUMMARY OF THE INVENTION

[0007] The primary aspect of the invention is to provide an auxiliary power unit heating system, and more particularly, an auxiliary power unit heating system comprising a means for selectively isolating a cabin heating unit in the auxiliary power unit heating system from a main engine coolant system while also providing heating capability for the main engine.

[0008] Other aspects of the invention will be pointed out or made obvious by the following description of the invention and the accompanying drawings.

[0009] The invention comprises an engine heating system for vehicles comprising an engine, a vehicle compartment heating system including fluid conduits extending from the engine to a heating unit and extending back to the engine, an auxiliary power unit on the vehicle including an auxiliary engine having a water pump driven by the auxiliary engine including fluid conduits extending from the auxiliary engine to a second heating unit located in a compartment of the vehicle and extending back to the auxiliary engine, fluid conduits extending from the engine to the second heating unit and extending back to the engine, a valve disposed in the fluid conduit between the second heating unit and the engine, the valve capable of receiving a signal, a temperature switch for detecting a coolant temperature, the temperature switch providing a signal to operate the valve, the valve allowing coolant circulation through the second heating unit to the main engine when the main engine is in operation or the coolant temperature is greater than a predetermined temperature, and the valve closed when the main engine is not in operation or the coolant temperature is below a predetermined temperature.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The accompanying drawings, which are incorporated in and form a part of the specification, illustrate preferred embodiments of the present invention, and together with a description, serve to explain the principles of the invention.

[0011] FIG. **1** is a schematic diagram of the auxiliary power unit heating system.

[0012] FIG. **2** is a schematic diagram of the valve position versus coolant temperature.

[0013] FIG. **3** is a schematic diagram of the coolant flow when the auxiliary power unit is running and the coolant temperature is low.

[0014] FIG. **4** is a schematic diagram of the coolant flow when the auxiliary power unit is running and the cabin area is warm.

[0015] FIG. **5** is a schematic diagram of the system instrumentation.

[0016] FIG. **6** is a chart of various system and environmental temperatures.

[0017] FIG. **7** is a chart of example coolant flow rates.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0018] FIG. **1** is a schematic diagram of the auxiliary power unit heating system. The system comprises an auxiliary engine **100**, a main engine **200**, a rear heating unit **300** and a front heating unit **400**.

[0019] The auxiliary engine comprises a single or multi-cylinder internal combustion or diesel engine. The auxiliary engine uses the same fuel as the main engine, for example either diesel fuel or gasoline. The auxiliary engine is cooled by a conventional water jacket coolant system. The coolant system further comprises multiple fluid conduits (pipes) within which flows a fluid such as water mixed with a suitable proportion of glycol or equivalent type anti-freeze.

[0020] The coolant system further comprises a radiator **500** to which the fluid conduits for the main engine and the auxiliary engine are connected. The radiator disposes of system waste heat when either the auxiliary engine or main engine is operating and thermostat **600** is open allowing coolant flow to the radiator.

[0021] Main engine **200** is a known form of multi-cylinder diesel or internal combustion engine comprising reciprocating pistons, cylinders and so on. Main engine **200** comprises a block which is cooled by a conventional coolant system comprising a fluid such as water mixed with a suitable proportion of glycol or equivalent type anti-freezes.

[0022] A thermostat **600** controls flow of the coolant though the radiator **500**. The thermostat is known in the art and is activated based upon the temperature of the coolant circulating in the system. The thermostat opens upon reaching a predetermined temperature, for example, 180° F. The thermostat is known in the art and may either be mechanical or electrically controlled.

[0023] The coolant system comprises input fluid conduit **301** and output conduit **302** from rear heating unit **300**. Rear heating unit **300** is used to provide heat to a vehicle compartment, for example, the sleeper area of a long haul truck's cabin. A normally open valve (NOV) **700** is placed in the return conduit **303** which returns the coolant to the main engine **200** after it has passed through rear heating unit **300**. However, valve **700** could also be placed in output conduit **304** between the main engine **200** and rear heating unit **300** and the system function will be identical in either configuration as described herein.

[0024] Temperature switch **800** is located in conduit **301**. Conduit **301** is connected to conduit **304** and conduit **309**. Conduit **301** supplies coolant to the rear heating unit **300**. Temperature switch **800** controls the state of valve **700**, that is, it controls whether valve **700** is open or closed based upon the temperature of the coolant and the state of relay **801**.

[0025] Main Engine Operating

[0026] In the mode when the main engine **200** is running, main engine water pump **201** pumps coolant to front heating unit **400** through conduit **305** and the return flow returns to the main engine **200** through conduit **306**. Coolant also flows through conduit **304** toward the rear heating unit **300**. Some coolant flowing toward rear heat unit **300** simultaneously flows into the auxiliary engine **100** through conduit **309**. At a predetermined temperature thermostat **600** opens and a portion of the coolant flow then also flows through radiator **500**. The return flow from the auxiliary engine and the radiator collects into conduit **308** and flows to conduit **307**.

[0027] The coolant leaving rear heating unit **300** through conduit **307** and the auxiliary engine **100** and the radiator through conduit **308**, flows through valve **700** and conduit **303** to return to the main engine **200** to repeat the cycle.

[0028] When the main engine **200** is operating, electrical relay **801** is normally open thereby preventing electrical power from reaching temperature switch **800**, and consequently valve **700** in the case when temperature switch **800** is closed. However, even in the case when temperature switch **800** is closed because the coolant temperature is above its predetermined temperature set point, for example 180° F., in the case when the main engine **200** is operating and the relay **801** is open no power will flow to the valve **700**, thereby assuring that normally open valve **700** remains open.

[0029] In the operating mode where only the main engine is operating, the advantage of having some coolant flow through the auxiliary engine is that the auxiliary engine will stay warmed even though it is not operating. This assures an easy start when the auxiliary power unit is required to provide to operate and heat.

[0030] Water pump **101** and water pump **201** are each "flow-through" pumps, known in the art. This means each does not significantly restrict fluid flow though the pump when the pump is not rotating, for example, when either the auxiliary engine or the main engine is not operating but fluid is still flowing through the system.

[0031] Auxiliary Engine Operating/Main Engine Shut Down

[0032] When the main engine is shut down, for example, when the vehicle is parked, and the auxiliary power unit is started, relay **801** closes (main engine off) thereby providing electrical power to temperature switch **800**. Power to temperature switch **800** does not necessarily mean that valve **700** is energized. Temperature switch **800** operation, and thereby valve **700** operation in part, is dependent upon coolant temperature.

[0033] If the vehicle has not been operating for a period of time and the coolant is cold, for example, below the temperature switch lower temperature threshold ~150° F., temperature switch **800** will be closed as demonstrated in the switch logic in FIG. **2**. FIG. **2** is a schematic diagram of the valve position versus coolant temperature.

[0034] In this situation auxiliary engine **100** is started and the coolant begins circulating. Until the temperature switch upper limit (~180° F.) has been exceeded by circulation of the steadily warming coolant, the closed temperature switch **800** provides power to the normally open valve **700**, causing valve **700** to be closed and thereby stopping return coolant flow through conduit **303** to main engine **200**. This isolates the auxiliary engine **100** and rear heating unit **300** from the rest of the coolant system, thereby speeding heating of the relatively smaller volume of the auxiliary engine portion of the cooling system. This configuration is shown in FIG. **3**. FIG. **3** is a schematic diagram of the coolant flow when the auxiliary engine is running and the coolant temperature is low.

[0035] With valve **700** closed coolant circulates from the auxiliary engine **100** to rear heating unit **300** and back to the auxiliary engine **100**. A portion of the coolant may also circulate through radiator **500** depending upon the temperature set point for thermostat **600**. Since the amount of coolant circulating in this configuration is less than the total system volume, the coolant will heat up relatively quickly to provide heat to the cabin. On the other hand, if the entire volume of the coolant in the system had to be heated as in a prior art system, the temperature of the coolant will rise very slowly because of the limited heat production of the auxiliary engine. Consequently, it would take a relatively longer time to heat the cabin and sleeper area.

[0036] Once the temperature of the coolant rises above the upper temperature threshold (~180° F.) temperature switch **800** opens thereby denergizing valve **700** which causes valve **700** to open since it is a normally open valve (NOV), i.e., energizing valve **700** closes valve **700**.

[0037] With valve **700** open the auxiliary engine **100** pumps coolant through conduit **309** and conduit **301** to rear heating unit **300** and to the main engine through conduit **304**. The coolant flow from rear heating unit combines with flow from conduit **303** returning from the main engine **200**. The combined flow returns to the auxiliary engine through conduit **307**. This is shown in FIG. **4**. FIG. **4** is a schematic diagram of the coolant flow when the auxiliary power unit is running and the cabin area is warm.

[0038] The coolant returning from the main engine **200** mixes with the return coolant from rear heating unit **300** which then flows back into the auxiliary engine water pump **101**. Since valve **700** is open and hot coolant from the rear heating unit **300** and cold coolant from the main engine **200** is mixing, the temperature of the coolant flowing through the auxiliary engine will decrease over time to a level were temperature switch **800** will close, thereby closing valve **700**. This will again isolate a small volume of coolant which circulates between the auxiliary engine **100** and the rear heating unit **300**. This will in turn quickly heat the coolant in the shortened loop until it is heated to the temperature where the valve **700** opens as described in this specification.

[0039] The cycle of closing and opening valve **700** will then continue based on the temperature of the coolant sensed by the temperature switch **800**. This control strategy enables the heat produced by the auxiliary engine to first warm cabin sleeper area and then excess heated coolant is routed to warm the main engine **200**.

[0040] In this configuration no heat is wasted by having the coolant flow through radiator **500** since the opening temperature for thermostat **600** is chosen to be above the upper closing threshold for temperature switch **800** (>~190° F.). Of course, thermostat **600** may open in the case of an unplanned system temperature excursion.

[0041] FIG. **5** is a schematic diagram of the system instrumentation. Thermocouples are used to detect cabin interior ambient temperature **1000**, exterior ambient temperature **1001**, front heating unit inlet coolant temperature **1002**, rear heating inlet coolant temperature **1003**, coolant return temperature **1004**, rear heating outlet coolant temperature **1005**, thermostat outlet coolant temperature **1006** and rear heating air outlet temperature **1007**. The temperature signals from each of the subject thermocouples may be used to measure system performance and may also be used by a vehicle ECU to optimize system operation. OF course, the system may also comprise minimal control intervention relying solely on the electrical operation of the temperature switch **800** and valve **700** and the thermostat set point. Example readings from the noted thermocouples for an example system are depicted in FIG. **6**.

[0042] FIG. **6** is a chart of various system and environmental temperatures. The cyclic nature of system is evident as well as the rapid rise in the coolant temperature in the auxiliary engine coolant loop when only the auxiliary engine in operation. After the coolant has warmed the slow rise in the main engine temperature is demonstrated. The relatively slow rise time is due to periodic coolant flow to the front heating unit **400** from the main engine **200**. In FIG. **6**, the curves depicted on the chart correspond to the following data noted in FIG. **5** as follows:

[0043] Front Heater In—**1002**

[0044] Rear Heater Out—**1005**

[0045] Exterior Temp—**1001**

[0046] Rear Register—**1007**

[0047] Return Temp—**1004**

[0048] Thermostat Open—**1006**

[0049] Interior Ambient—**1000**

[0050] Rear Heater In—**1003**

[0051] The information depicted in FIG. **6** is provided only as an example and is not intended to limit the operating capabilities, characteristics or configurations of the system. The relatively steady Interior Ambient **1000** temperature is readily apparent. The cyclic nature of the system is clearly illustrated as well.

[0052] FIG. **7** is a chart of example coolant flow rates. The position of valve **700** is shown in the column marked "NO Valve". "Flow out AE" is measured in conduit **309**. "Flow into Rear Heater" is measured in conduit **301**. "Flow into Main Engine" is measured in conduit **303**. The flow rates are in gallons per minute. The information depicted in FIG. **7** is only presented as a non-limiting example since the coolant flow rates will vary depending upon the particular water pump curve, the dimensions of the various conduits, and any other components that may be installed in any particular the system.

[0053] Although a form of the invention has been described herein, it will be obvious to those skilled in the art that variations may be made in the construction and relation of parts without departing from the spirit and scope of the invention described herein.

We claim:

1. An engine heating system for vehicles comprising:

an engine;

a vehicle compartment heating system including fluid conduits extending from the engine to a heating unit and extending back to the engine;

an auxiliary power unit on the vehicle including an auxiliary engine having a water pump driven by the auxiliary engine including fluid conduits extending from the auxiliary engine to a second heating unit located in a compartment of the vehicle and extending back to the auxiliary engine;

fluid conduits extending from the engine to the second heating unit and extending back to the engine;

a valve disposed in the fluid conduit between the second heating unit and the engine, the valve capable of receiving a signal;

a temperature switch for detecting a coolant temperature, the temperature switch in electrical communication with the valve and the temperature switch energizing the valve upon detection of a predetermined coolant temperature;

the valve allowing coolant circulation through the second heating unit to the main engine when the main engine is in operation or when the coolant temperature is greater than a predetermined temperature; and

the valve closed when the main engine is not in operation or when the coolant temperature is below a predetermined temperature.

2. The engine heating system as in claim 1, wherein the temperature switch is inoperable when the engine is in operation and the temperature switch is operable when the engine is not in operation.

3. The engine heating system as in claim 1 further comprising:

a relay for energizing the temperature switch; and

the relay is open during operation of the main engine.

4. The engine heating system as in claim 1, wherein the valve is normally open.

* * * * *