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(54) **USE OF A PHASE CHANGE MATERIAL SYSTEM**

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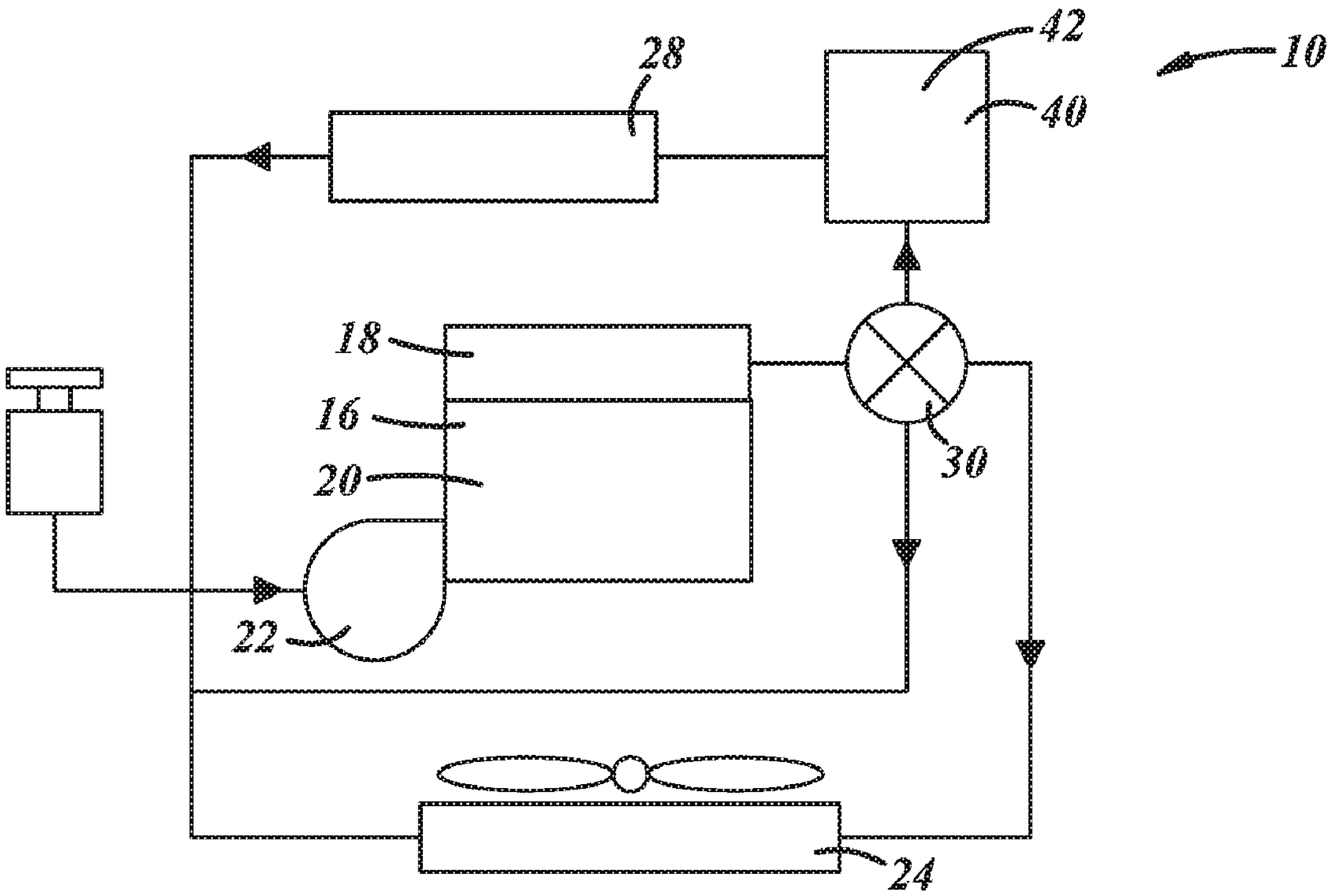
(57) **ABSTRACT**

A number of variations may include a vehicle system which includes an engine. The vehicle system may also include a phase change material which may be disposed in a phase change material device. The phase change material may be released into a vehicle cooling system upon user command. The PCM device may be constructed and arranged to increase a temperature of a vehicle cabin without the engine being turned on when the phase change material is released.



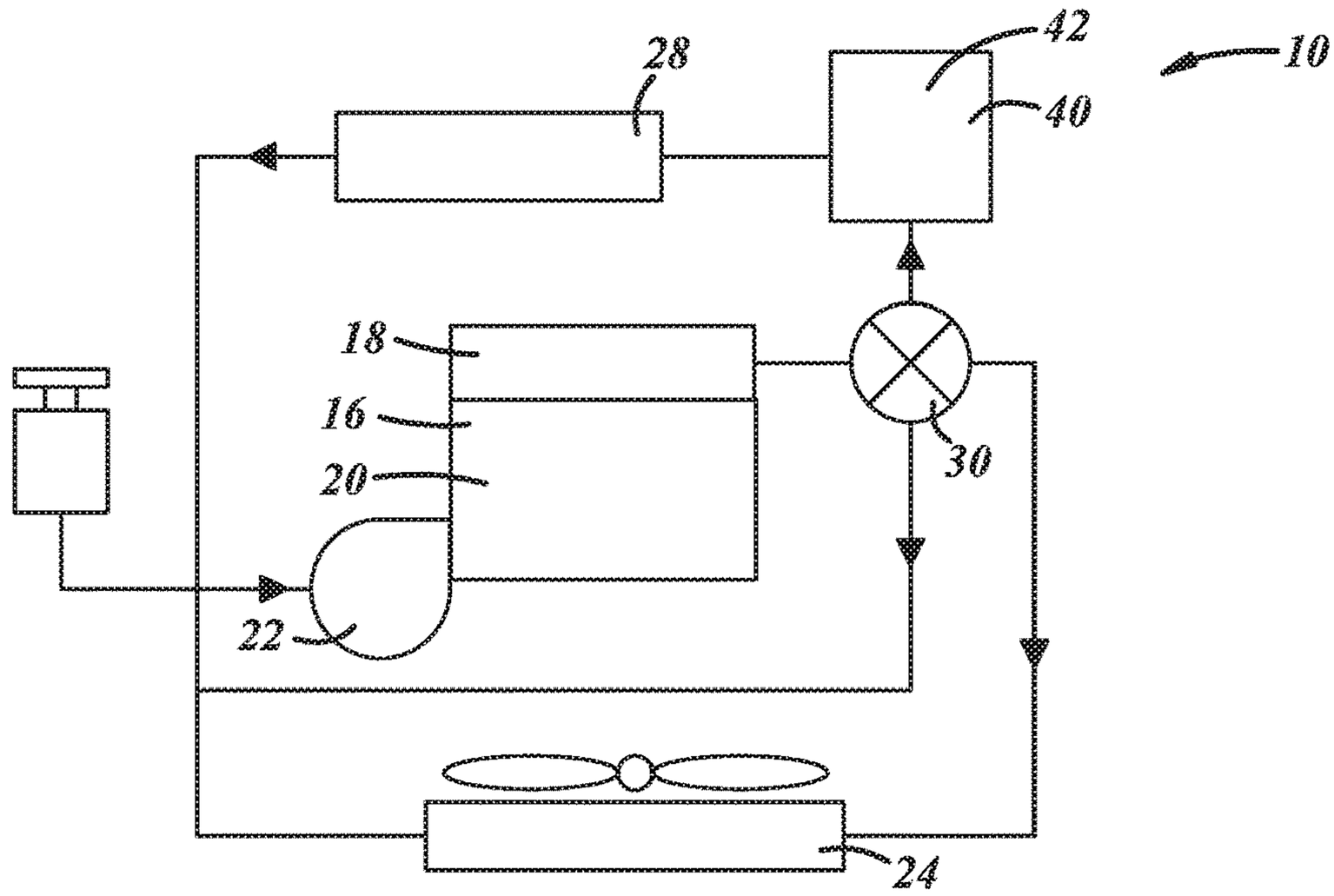


FIG. 1

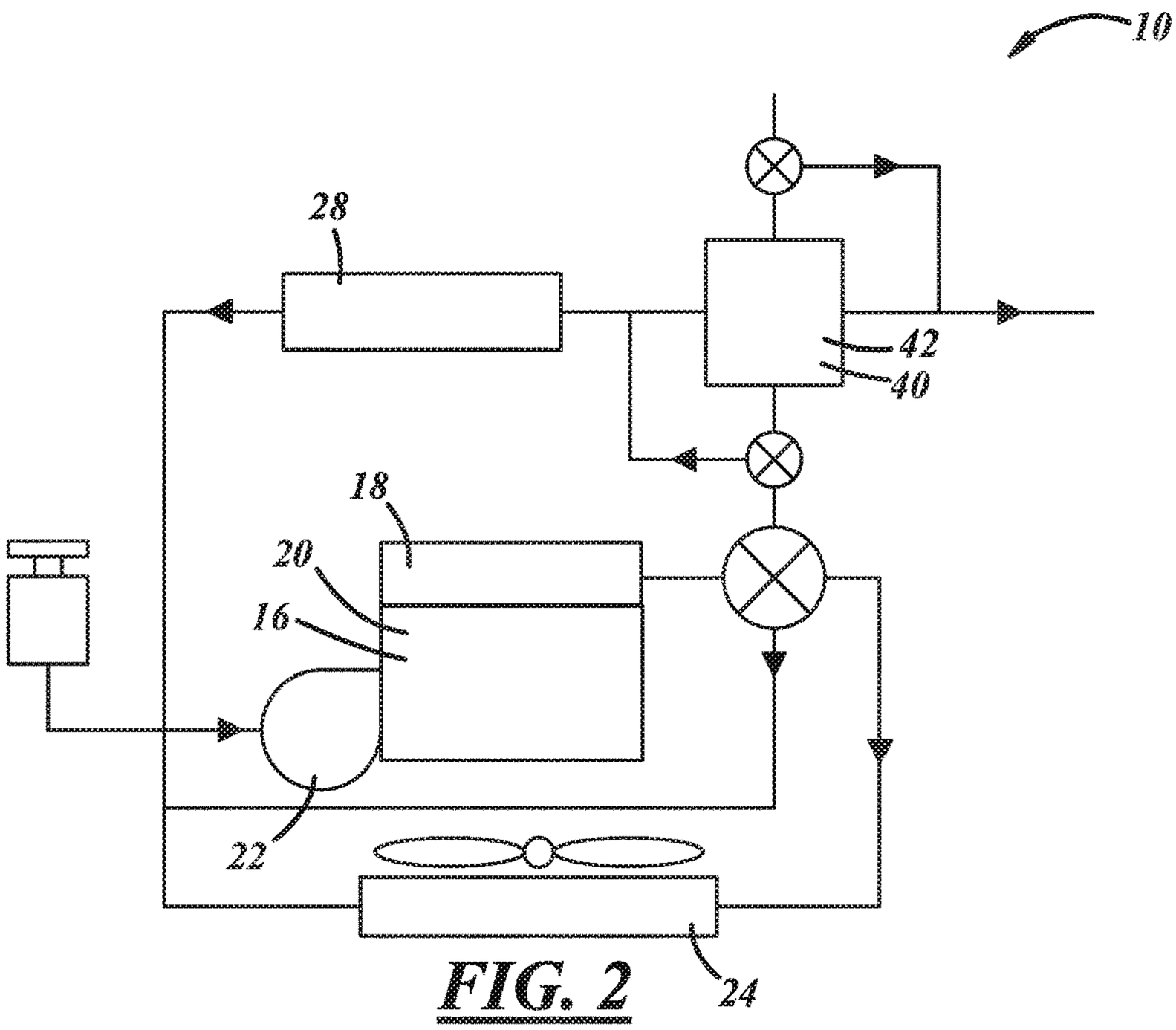


FIG. 2

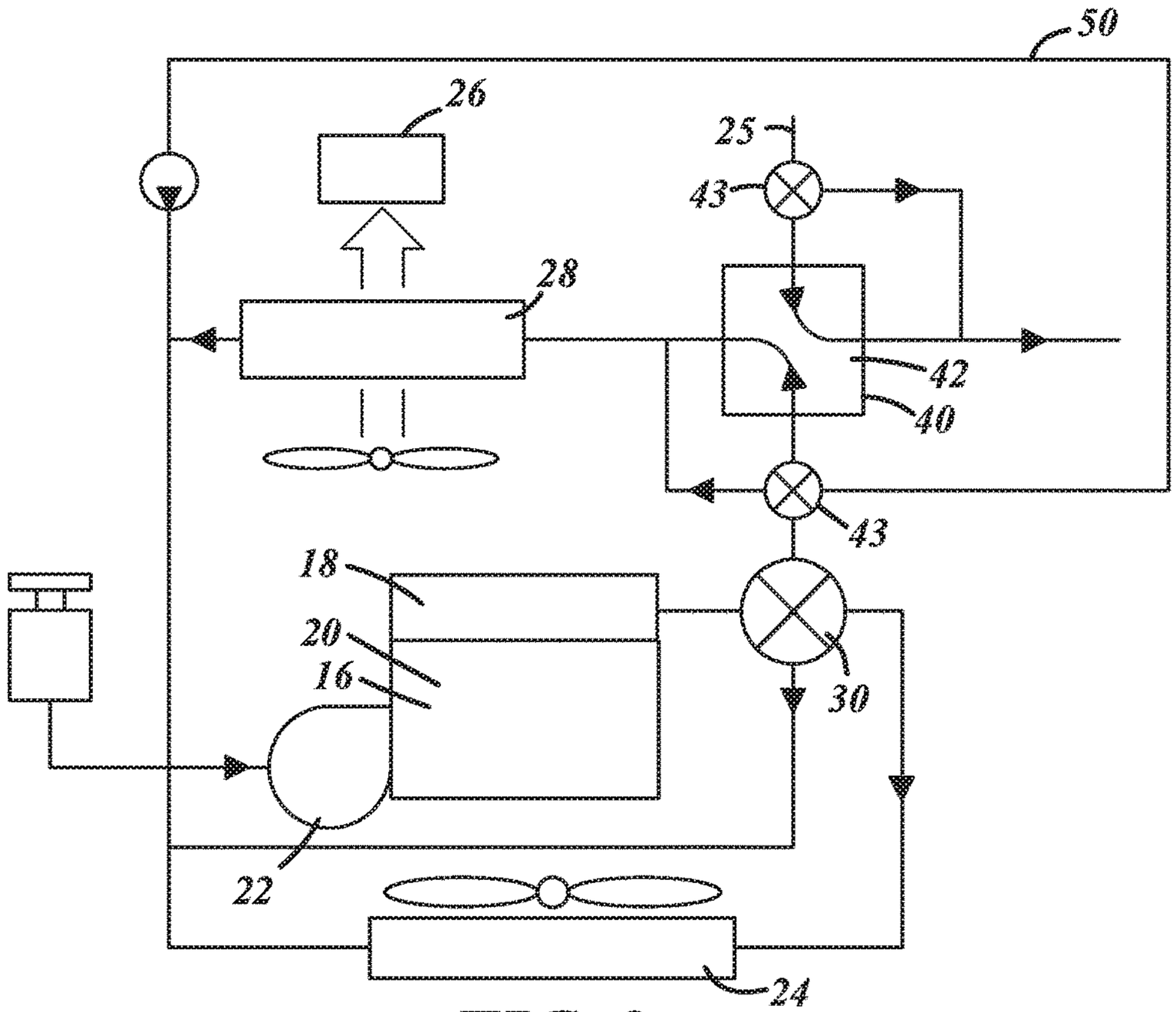


FIG. 3

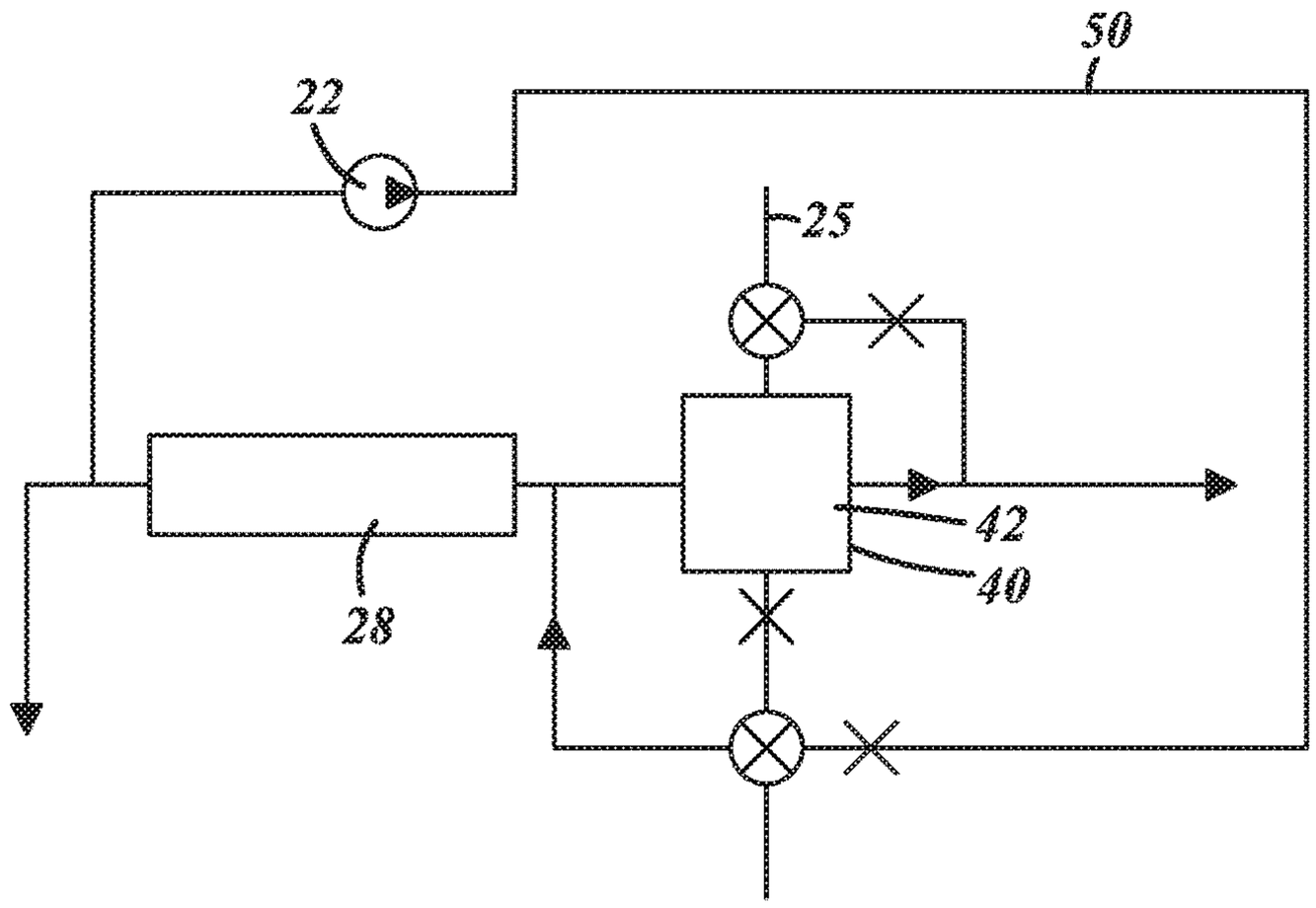


FIG. 4A

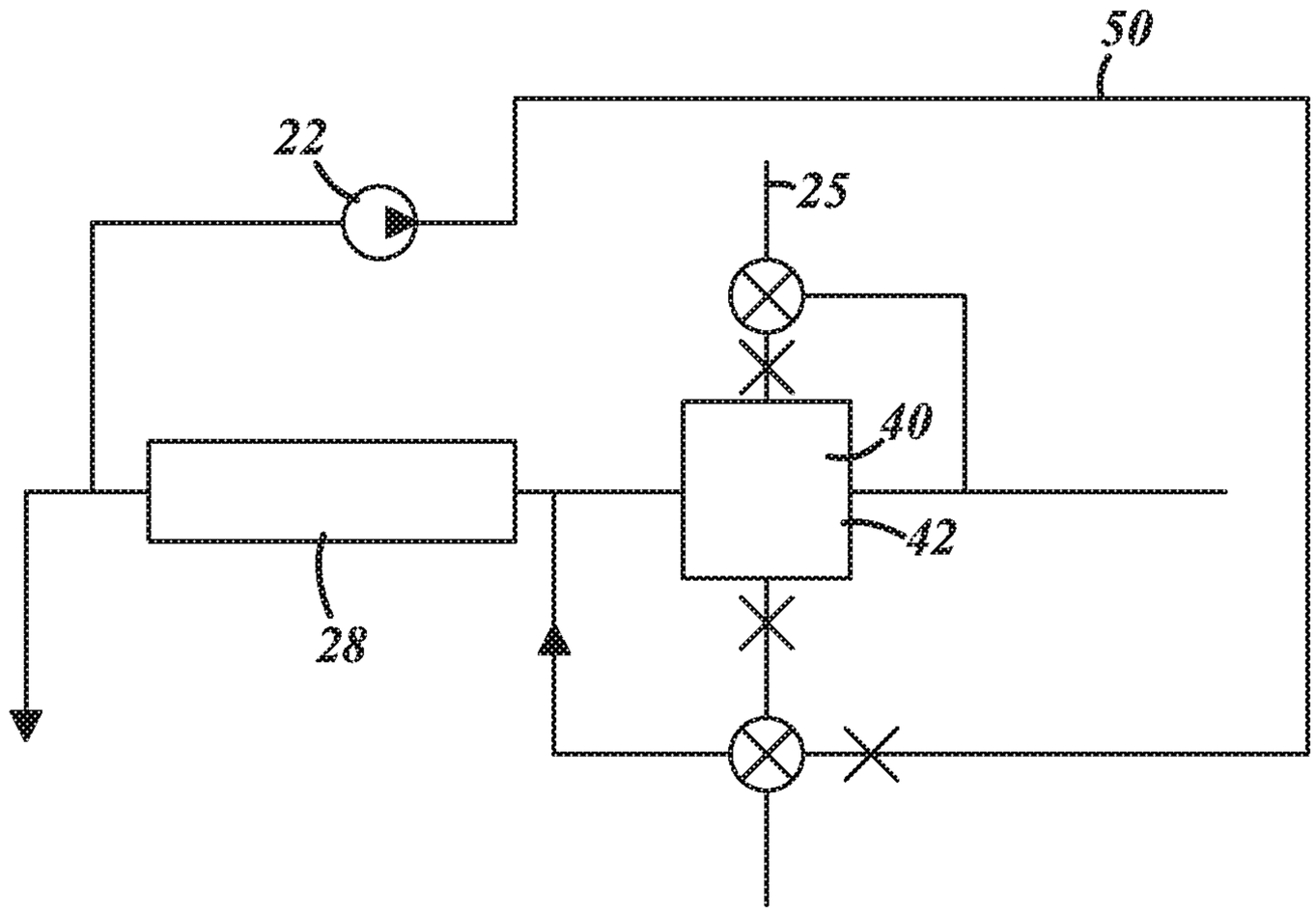


FIG. 4B

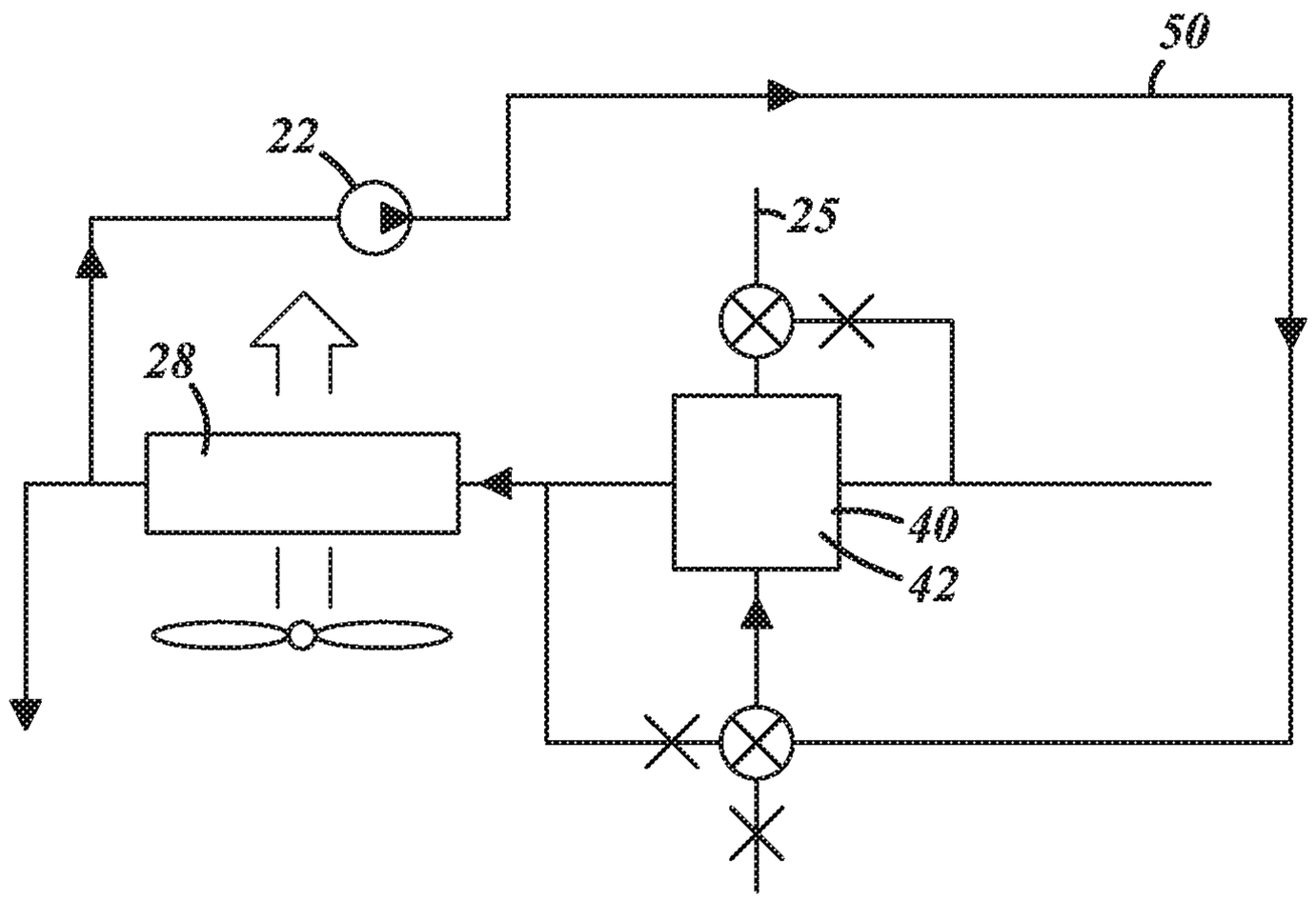


FIG. 4C

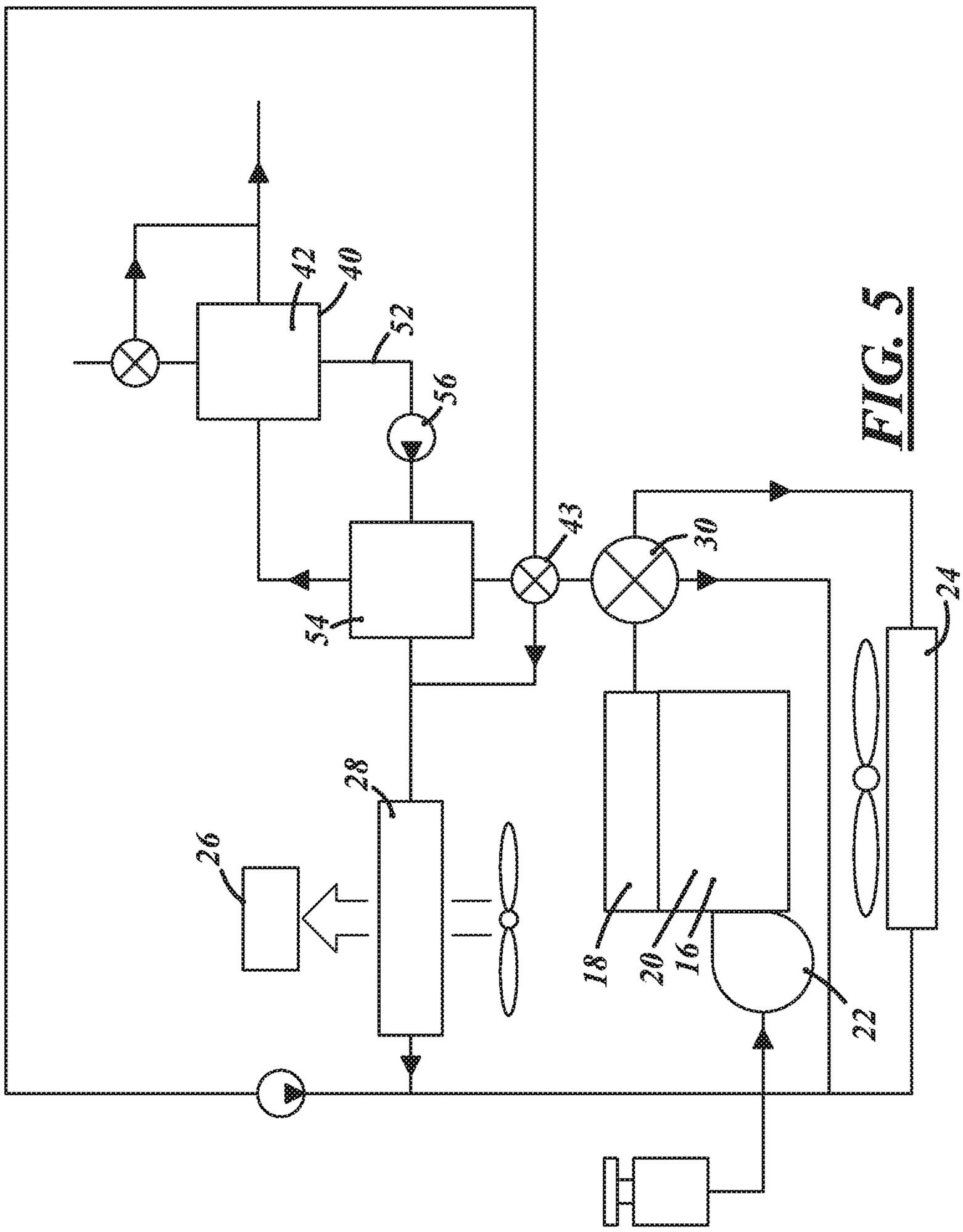


FIG. 5

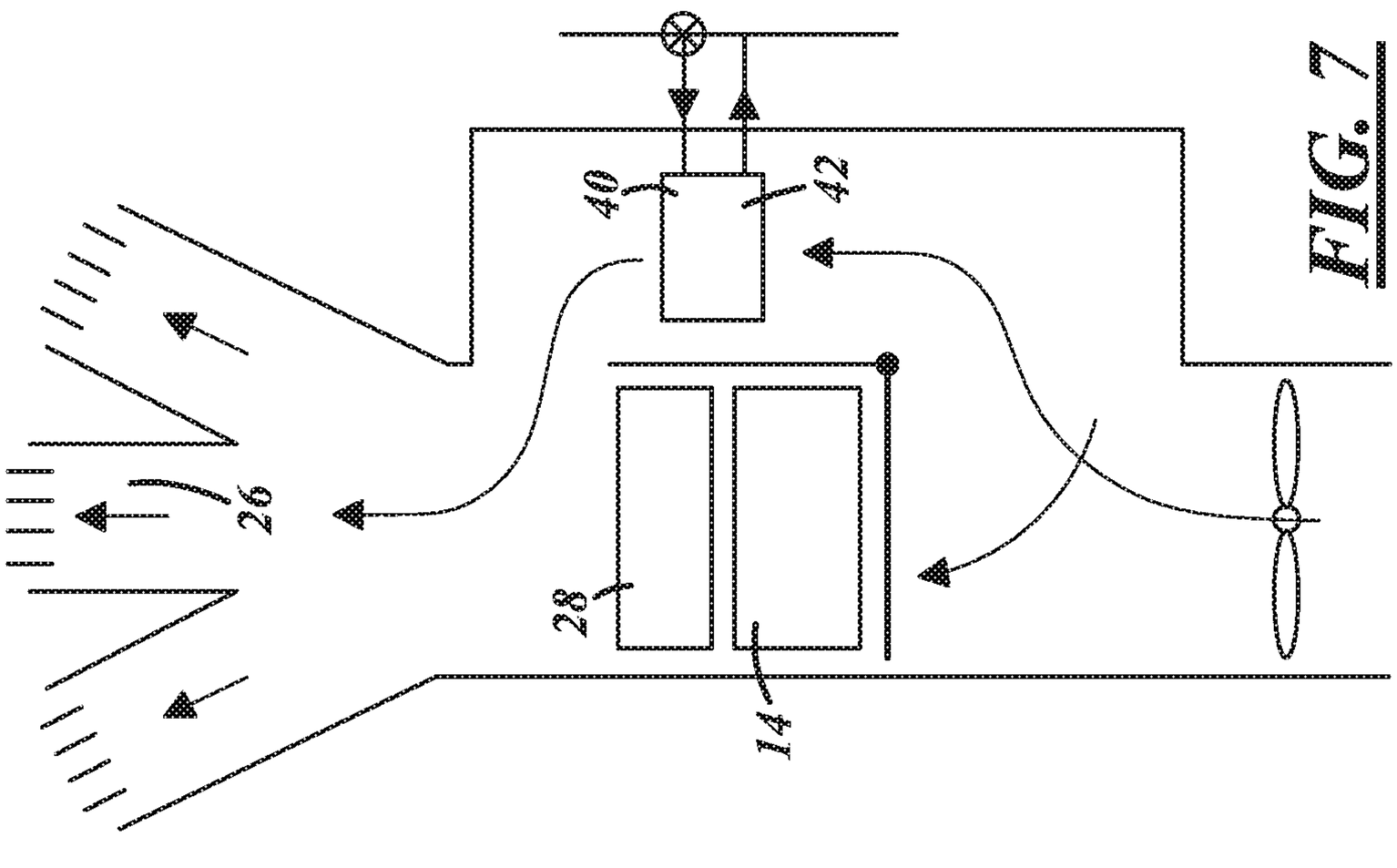


FIG. 7

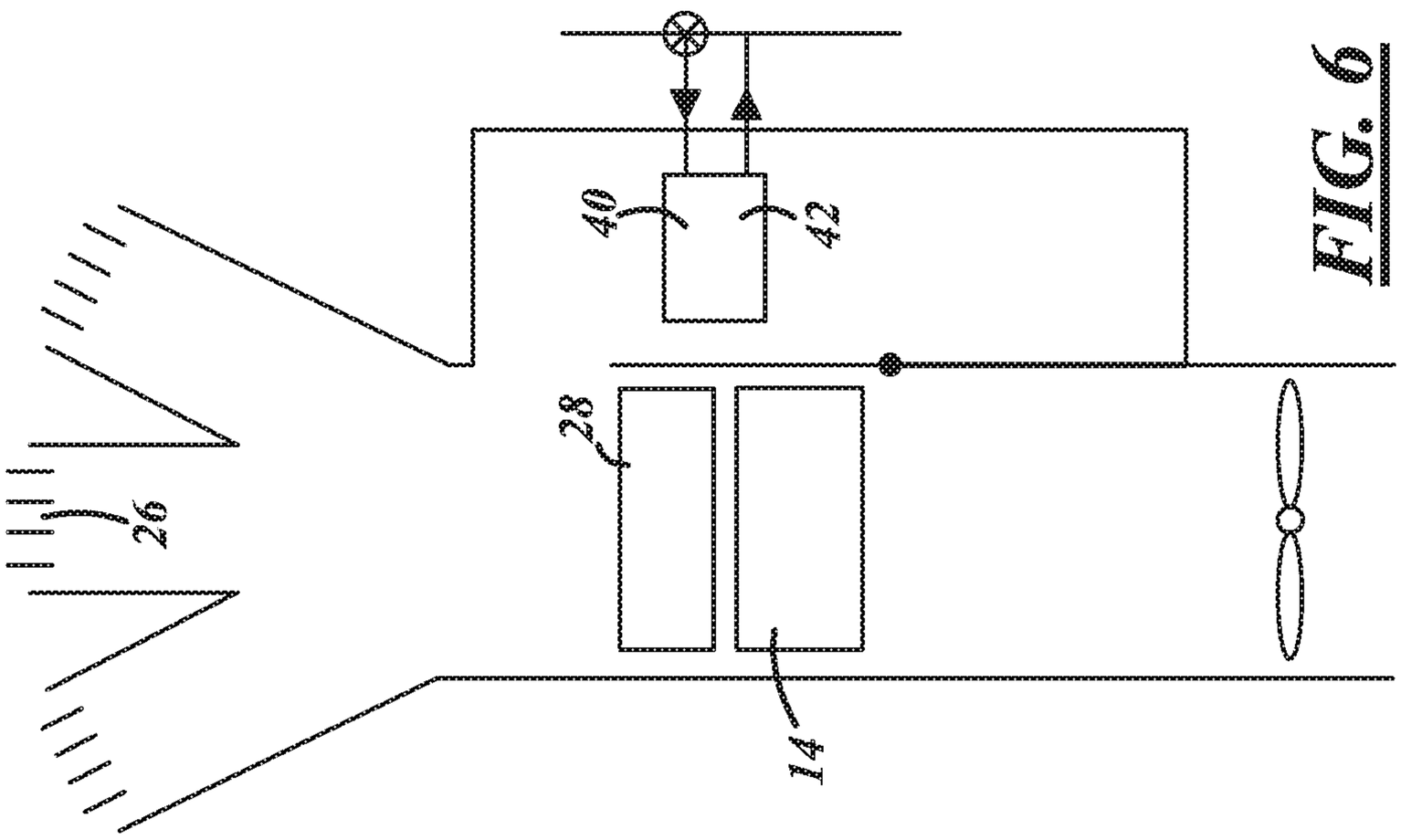


FIG. 6

USE OF A PHASE CHANGE MATERIAL SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of the U.S. Provisional Application No. 62/138,714 filed Mar. 26, 2015 and U.S. Provisional Application No. 62/142,281 filed Apr. 2, 2015.

TECHNICAL FIELD

[0002] The field to which the disclosure generally relates to includes vehicle cooling systems.

BACKGROUND

[0003] Vehicles may include various cooling systems.

SUMMARY OF ILLUSTRATIVE VARIATIONS

[0004] A number of variations may include a vehicle system which includes an engine. The vehicle system may also include a phase change material (PCM) which may be disposed in a phase change material device. The phase change material may be released into a vehicle cooling system upon user command. The PCM device may be constructed and arranged to increase a temperature of a vehicle cabin without the engine being turned on when the phase change material is released.

[0005] A number of other variations may include a method which may include providing a phase change material which may be disposed in a phase change material device. The phase change material device may be constructed and arranged to preheat a vehicle cabin prior to a vehicle engine being activated.

[0006] A number of other variations may include a method of heating a vehicle cabin which may include first providing a phase change material wherein the phase change material may be disposed in a phase change material device. Next, the phase change material may be activated upon a user command. Activating the phase change material may cause an increase in temperature in the vehicle cabin while a vehicle engine may not be activated.

[0007] Other illustrative variations within the scope of the invention will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples, while disclosing variations within the scope of the invention, are intended for purposes of illustration only and are not intended to limit the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Select examples of variations within the scope of the invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0009] FIG. **1** shows a schematic illustration of a vehicle assembly according to a number of variations of the present invention;

[0010] FIG. **2** shows a schematic illustration of the vehicle assembly according to a number of variations of the present invention;

[0011] FIG. **3** shows a schematic illustration of the vehicle system according to a number of variations of the present invention;

[0012] FIG. **4**A shows a schematic illustration of the vehicle system according to a number of variations of the present invention;

[0013] FIG. **4**B shows a schematic illustration of the vehicle system according to a number of variations of the present invention;

[0014] FIG. **4**C shows a schematic illustration of the vehicle system according to a number of variations of the present invention;

[0015] FIG. **5** shows a schematic illustration of the vehicle system according to a number of variations of the present invention;

[0016] FIG. **6** shows a schematic illustration of the vehicle system according to a number of variations of the present invention; and

[0017] FIG. **7** shows a schematic illustration of the vehicle system according to a number of variations of the present invention.

DETAILED DESCRIPTION OF ILLUSTRATIVE VARIATIONS

[0018] The following description of the variations is merely illustrative in nature and is in no way intended to limit the scope of the invention, its application, or uses.

[0019] Referring now to the variations illustrated in FIGS. **1-7**, a vehicle system **10** may be provided and may include a phase change material **42** which may be operable coupled to a vehicle HVAC system **14**. The vehicle system **10** may also include the vehicle engine **16**. The vehicle engine **16** may be a standard engine as known by one of ordinary skill in the art and may include a head portion **18** and a block portion **20**. Additionally, the vehicle system **10** may include at least one pump **22** which may be constructed and arranged to pump coolant or other fluid through the vehicle system **10**. Moreover, the vehicle system **10** may include a heat exchanger **24** and the vehicle HVAC system **14**. The HVAC system **14** may be constructed and arranged to blow air from the vehicle system **10** into a vehicle cabin **26** in order to provide a comfortable climate to a vehicle passenger. The HVAC system may additionally include a heat source **25**. The heat source may be an exhaust system or other type of heat source as known by one of ordinary skill in the art.

[0020] The vehicle system **10** may also include a cabin heater **28** which may be constructed and arranged to provide heat. Additionally the HVAC system **14** may include an evaporator **29**. It is contemplated that the HVAC system **14** may be constructed and arranged to blow heat from the cabin heater **28**, through the evaporator **29**, into the vehicle cabin **26**. Moreover, the vehicle system **10** may include at least one control device **30**. The at least one control device **30** may be a valve, a bypass valve, a thermostatic device or another control device as known by one of ordinary skill in the art. It is contemplated, as illustrated in FIGS. **2-6**, the vehicle system **10** may include more than one control device **30**. The control device **30** may be placed in any location on the vehicle system **10** including but not limited to prior to the entrance of a phase change material (PCM) device, after the PCM device, or to start or stop an alternate loop, as known by one of ordinary skill in the art.

[0021] Referring again to the variations illustrated in FIGS. **1-7**, the vehicle system **10** may additionally include

the phase change material device **40** (PCM device). The PCM device **40** may be constructed and arranged to transfer heat energy to the HVAC system **14** without activating the vehicle engine **16**. As illustrated in the variation shown in FIG. **1**, the PCM device **40** may be operably coupled to the cabin heater **28**, the engine **16**, the heat exchanger **24**, or any other portion of the vehicle system **10**. It is contemplated that a phase change material **42** may be incorporated into the vehicle system **10** and the phase change material **42** may be used to store and discharge energy into the system **10** for warming or cooling. In a number of variations, the phase change material **42** may include at least one of a pure salt, a metal, a hydrated salt, a hydrated salt in solution, an organic material, or other phase change or latent heat materials as known by one of ordinary skill the art.

[0022] Referring now to the variation illustrated in FIG. **2**, the vehicle system may include at least one valve **43**. The valve **43** may be a control valve or any other type of valve as known by one of ordinary skill in the art. It is contemplated that the valve **43** may be constructed and arranged to control charge and discharge of the PCM material **42** and PCM device **40**.

[0023] Referring now to the variations illustrated in FIGS. **1-7**, in operation, a user may enable the vehicle system **10**. The user may start the vehicle system **10** remotely using a remote device, or by any other means as known by one of ordinary skill in the art. Once the user enables the vehicle system **10**, the vehicle system **10** may operate without starting the engine. Once the vehicle system **10** is activated, the vehicle system, using the PCM material **42**, may heat the coolant, or other fluid, and the heat may be transferred from the coolant or other fluid into the cabin **26** via the cabin heater **28** or other heat exchanger system. The vehicle system **10** may be configured to heat the overall cabin air volume or at least some portion of the overall cabin air volume in order to increase the temperature of the vehicle cabin and to provide a heated vehicle cabin **26** for a user.

[0024] In operation, it is contemplated that during a previous running of the vehicle engine **16**, heat energy may be harvested from a source through a form of a heat exchanger. The source from which the heat energy may be harvested may be a cooling system, oil system, liquid system, fluid system, exhaust system or other vehicle system as known by one of ordinary skill in the art. It is contemplated that the heat energy may then be stored in the phase change material **42** which may be disposed in the PCM storage device **40**. Additionally it is contemplated that the heat energy may be stored in the phase change material **42** for up to approximately 72 hours, for example up to 48 hours or up to 28 hours. The user may activate the vehicle system **10** within the vehicle, or remotely. When the system **10** is activated, the system **10** may use the cooling system or exhaust system which may be connected to the PCM device **40** in order to transfer the heat from the phase change material **42** through the cooling system and into the cabin heater **28**. It is contemplated that an electric coolant pump **22** may be used in order to help move the fluid through the cooling system. Additionally it is contemplated that any other form of pump may be used to move the fluid through the cooling system. Once the heat is transferred to the cabin heater **28**, the vehicle HVAC system **14** may be switched on in order to transfer the heat from the cabin heater **28** into the vehicle cabin **26**.

[0025] Moreover, it is contemplated that the PCM device **40** may be directly attached to the HVAC system **14** which may bypass the cooling system and cabin heater **28**. Since the vehicle engine **16** is not turned on or activated during the heating of the vehicle cabin or during operation of the vehicle system, no fuel is consumed during operation of the vehicle system **10** and further no fuel or other emissions are released into the atmosphere during the warming phase of the vehicle.

[0026] Referring now to the variation illustrated in FIG. **1**, the vehicle system **10** may use coolant as the heat source in order to melt the PCM **42** when the coolant is hot (charging) and may additionally use the coolant in order to remove the heat energy from the PCM **42** when the coolant is cold by solidifying the PCM (discharging) as the heat transfer medium for the vehicle system. The particular PCM **42** used for this system may be based around lower temperatures close to coolant operating temperatures in order to provide the best net energy differential in order to provide optimal charging and discharging. It is also contemplated that any type of PCM may be used.

[0027] Referring now to the variation illustrated in FIG. **2**, the system **10** may use exhaust energy for the charging portion and additionally may use coolant for the heat transfer medium to the PCM **42**. The specific PCM **42** used for this system as illustrated in FIG. **2**, may be a higher temp phase change material. It is also contemplated that any PCM **42** may be used. Additionally, the PCM device **40** may be operable coupled to the exhaust system and may additionally include an exhaust bypass valve.

[0028] Referring now to the variation illustrated in FIG. **3**, the vehicle system **10** may include an additional fluid loop **50** in order to allow the fluid to be circulated without using the main fluid pump and without flowing through the engine. As illustrated in FIG. **3**, the additional loop **50** may use the same fluid as the original loop. It is contemplated that the additional loop may allow the fluid to be pumped around only through the PCM device **40** and the cabin heater **28**. Moreover, the vehicle system **10** may use the additional fluid loop **50** for discharging operation as the heat transfer medium for the PCM **42**. Moreover, the PCM **42** used in the variation illustrated in FIG. **3**, may be a high temp phase change material, or any other PCM as known by one of ordinary skill in the art.

[0029] Referring now to the variations illustrated in FIGS. **4A-4C**, the vehicle system **10** may additionally include an additional fluid loop. During the charging operation illustrated in FIG. **4A**, the additional loop **50** may have no flow and may operate similar to the variations described above. As illustrated in FIG. **4B**, during the storage operation, the vehicle system **10** may have no flow and everything is off including the pump **22** for both the original fluid loop and the additional fluid loop **50**. As illustrated in FIG. **4C**, during discharge, the additional fluid may be pumped and the fluid may flow between the PCM device **40** and the cabin heater **28**. As similarly described above, the HVAC system **14** may be operably coupled to the cabin heater **28** in order to move the heat from the cabin heater **28** into the vehicle cabin **26**.

[0030] Referring now to the variation illustrated in FIG. **5**, the vehicle system **10** may include an intermediate fluid loop **52** in order to prevent coolant boiling due to the high temperature PCM **42**. The intermediate fluid loop **52** may be constructed and arranged to allow heat to be transferred from the PCM **42** to the intermediate fluid loop **52**, to the

main fluid loop, and then through the cabin heater and into the vehicle cabin while the vehicle engine is off. It is contemplated that the intermediate fluid loop **52** may include an intermediate fluid and additionally or alternatively may include an intermediate fluid pump **56**. The intermediate fluid may allow heat from the PCM device **40** or heat source to an intermediate heat exchanger **54**, which may allow heat into the main cooling loop and which may allow heat into the vehicle cabin **26** via the cabin heater **28**.

[0031] Referring now to the variations illustrated in FIGS. **6** and **7**, it is contemplated that the HVAC system **14** may be directly operably coupled to the PCM device **40**. As illustrated in FIG. **6**, the HVAC system **14** may be configured to move air directly from the evaporator **29** to the cabin heater **28** and then into the vehicle cabin **26**. As additionally illustrated in FIG. **7**, the HVAC system **14** may be additionally or alternatively configured to blow air directly from the PCM device **40** into the vehicle cabin **26**. It is additionally contemplated that the HVAC system **14** may be constructed and arranged to blow air from both the PCM device **40** and the evaporator **29**/cabin heater **28** into the vehicle cabin **26**. This system may be used with any of the other vehicle systems as shown in FIGS. **1-7**. Moreover, the PCM device **40** as illustrated in FIGS. **6** and **7** may be charged by any of the previous methods as described above and/or illustrated in FIGS. **1-7**.

[0032] The following description of variants is only illustrative of components, elements, acts, product and methods considered to be within the scope of the invention and are not in any way intended to limit such scope by what is specifically disclosed or not expressly set forth. The components, elements, acts, product and methods as described herein may be combined and rearranged other than as expressly described herein and still are considered to be within the scope of the invention.

[0033] Variation 1 may include a vehicle system which may include a phase change material device which may be operably coupled to a vehicle HVAC system. Additionally, the PCM device may be configured to transfer heat energy to the HVAC system without activating a vehicle engine.

[0034] Variation 2 may include the vehicle system as set forth in Variation 1 wherein the PCM device may be charged during previous operation of the vehicle engine.

[0035] Variation 3 may include the vehicle system as set forth in any of Variations 1-2 wherein the PCM device may be constructed and arranged to store heat energy.

[0036] Variation 4 may include the vehicle system as set forth in any of Variations 1-3 wherein the heat may be transferred from the PCM device to the HVAC system upon a user command.

[0037] Variation 5 may include the vehicle system as set forth in any of Variations 1-4 wherein the heat may be transferred from the HVAC system to a vehicle cabin.

[0038] Variation 6 may include vehicle system as set forth in any of Variations 1-5 and may further include a cooling system which may be operably coupled to the PCM device.

[0039] Variation 7 may include the vehicle system as set forth in any of Variations 1-6 wherein the cooling system may be constructed and arranged to transfer the heat energy from the PCM device to the HVAC system.

[0040] Variation 8 may include a method which may include harvesting heat energy while a vehicle engine is running. Next, the vehicle engine may be turned off. The heat energy may then be stored in a phase change material device. Additionally, the heat energy from the PCM device may be discharged upon a user command. The heat energy may then be transferred to a cabin heater. Finally, a blower may be operated in order to transfer the heat energy into a vehicle cabin which may warm the vehicle cabin while the vehicle engine is off.

[0041] Variation 9 may include the method as set forth in Variation 8, moreover a cooling system may be operably coupled to the PCM device.

[0042] Variation 10 may include the method as set forth in any of Variations 8 or 9 wherein the cooling system may be constructed and arranged transfer the heat energy from the PCM device to the HVAC system.

[0043] Variation 11 may include the method as set forth in any of Variations 8-10 wherein the user command may be given remotely.

[0044] Variation 12 may include the method as set forth in any of Variations 8-11 wherein no fuel may be consumed during warming of the vehicle cabin.

[0045] Variation 13 may include the method as set forth in any of Variations 8-12 wherein no emissions may be produced during warming of the vehicle cabin.

[0046] Variation 14 may include a method of warming a vehicle cabin without starting a vehicle engine and may include first harvesting heat energy during a previous running of the vehicle engine. Next, the heat energy may be stored in a phase change material device. Next, the heat energy may be discharged from the PCM device upon a user command. Finally, the heat energy may be used to heat the vehicle cabin.

[0047] Variation 15 may include the method of warming a vehicle cabin without starting a vehicle engine as set forth in Variation 14 and may further include transferring the heat energy to a cabin heater.

[0048] Variation 16 may include the method of warming a vehicle cabin without starting a vehicle engine as set forth in any of Variations 14 or 15 and may further include operating a blower in order to transfer the heat energy into the vehicle cabin.

[0049] Variation 17 may include the method of warming a vehicle cabin without starting a vehicle engine as set forth in any of Variations 14-16 and may further include operating a cooling system, wherein the cooling system may be constructed and arranged to transfer the heat energy from the PCM device to the HVAC system.

[0050] Variation 18 may include the method of warming a vehicle cabin without starting a vehicle engine as set forth in any of Variations 14-17 wherein the user command may be given remotely.

[0051] Variation 19 may include the method of warming a vehicle cabin without starting a vehicle engine as set forth in any of Variations 14-18 wherein no fuel may be consumed during warming of the vehicle cabin.

[0052] Variation 20 may include the method of warming a vehicle cabin without starting a vehicle engine as set forth in any of Variations 14-19 wherein no emissions may be produced during warming of the vehicle cabin.

[0053] The above description of select variations within the scope of the invention is merely illustrative in nature and, thus, variations or variants thereof are not to be regarded as a departure from the spirit and scope of the invention.

1. A vehicle system comprising:
a phase change material (PCM) device operably coupled to a vehicle HVAC system wherein the PCM device is configured to transfer heat energy to the passenger cabin without activating a vehicle engine.

2. The vehicle system of claim **1**, wherein the PCM device is charged during previous operation of the vehicle engine.

3. The vehicle system of claim **1**, wherein the PCM device is constructed and arranged to store heat energy.

4. The vehicle system of claim **1**, wherein heat is transferred from the PCM device to the passenger cabin upon a user command.

5. The vehicle system of claim **1**, wherein heat is transferred from the cabin heater to a vehicle cabin.

6. The vehicle system of claim **1**, further comprising a cooling system for cooling vehicle mechanical components or mechanical fluids, the cooling system being operably coupled to the PCM device.

7. The vehicle system of claim **6**, wherein the cooling system is constructed and arranged to transfer the heat energy from the PCM device to the passenger cabin.

8. A method comprising:
harvesting heat energy while a vehicle engine is running;
turning off the vehicle engine;
storing the heat energy in a phase change material (PCM) device;
discharging the heat energy from the PCM device upon user command;
transferring the heat energy to a cabin heater;
operating a blower to transfer the heat energy into a vehicle passenger cabin, thereby warming the passenger cabin while the vehicle engine is off.

9. The method of claim **8**, further comprising a cooling system for cooling vehicle mechanical components or mechanical fluids, wherein a cooling system is operably coupled to the PCM device.

10. The method of claim **9**, wherein the cooling system is constructed and arranged to transfer the heat energy from the PCM device to the passenger cabin.

11. The method of claim **8** wherein the user command is given remotely.

12. The method of claim **8** wherein no fuel is consumed during warming of the passenger cabin.

13. The method of claim **8** wherein no emissions are produced during warming of the passenger cabin.

14. A method of warming a vehicle cabin without starting a vehicle engine comprising:
harvesting heat energy during a previous running of the vehicle engine;
storing the heat energy in a phase change material (PCM) device;
discharging the heat energy from the PCM device upon user command; and
using the heat energy to heat the vehicle passenger cabin.

15. The method of claim **14** further comprising transferring the heat energy to a cabin heater.

16. The method of claim **15** further comprising operating a blower to transfer the heat energy into the vehicle cabin.

17. The vehicle system of claim **9**, further comprising operating a cooling system for cooling vehicle mechanical components or mechanical fluids wherein the cooling system is constructed and arranged to transfer the heat energy from the PCM device to the HVAC system.

18. The method of claim **14** wherein the user command is given remotely.

19. The method of claim **14** wherein no fuel is consumed during warming of the vehicle cabin.

20. The method of claim **14** wherein no emissions are produced during warming of the vehicle cabin.

21. A vehicle system comprising as set forth in claim **1** wherein the PCM comprises at least one of a pure salt, a metal, a hydrated salt or a hydrated salt in solution.

22. A method as set forth in claim **8** wherein the PCM comprises at least one of a pure salt, a metal, a hydrated salt or a hydrated salt in solution.

23. A method as set forth in claim **14** wherein the PCM comprises at least one of a pure salt, a metal, a hydrated salt or a hydrated salt in solution.

24. A method as set forth in claim **14** wherein harvesting heat energy comprises transferring heat from an engine of mechanical component cooling system, oil system, liquid system, fluid system, exhaust system.

* * * * *