

**DUAL-MODE AUTOMOBILE AIR-CONDITIONING SYSTEM
AND METHODS OF USE**

CROSS-REFERENCE TO RELATED APPLICATIONS

5 This patent application claims the benefit of U.S. Provisional Patent Application No. 61/436,993, filed on January 27, 2001, and U.S. Provisional Patent Application No. 61/436,993 is hereby incorporated by reference for all purposes. This patent application also claims the benefit of U.S. Provisional Patent Application No. 61/490,013, filed on May 25, 2011, and U.S. Provisional Patent Application No. 61/490,013 is also hereby incorporated by
10 reference for all purposes.

BACKGROUND

Most current air-conditioning systems for automobiles employ traditional refrigerant-compression system, wherein the refrigerant compressor is driven by a system of pulleys that transmit rotational energy directly from a running automobile engine. Such air-conditioning
15 systems are inoperable until a user actually starts the internal-combustion engine of the vehicle, after which the user can engage the air-conditioning system controls to cool the passenger compartment.

What is not possible with current systems is the ability to remotely start a vehicle's air-conditioning system without also running the engine. What would be useful and
20 convenient for users is an automobile air-conditioning system that can be driven by a fully electrical power source, preferably renewable, when the engine of the vehicle is not running. Moreover, it would be desirable for such a system to be able to be communicatively coupled and controlled by a user using a wireless device such as a cellular phone application or a keyless radio-frequency controller.

BRIEF DESCRIPTION OF THE DRAWINGS

25 **Figure 1A** depicts an embodiment of an automobile air-conditioning system refrigerant compressor that is adapted to be driven either by the vehicle engine via a pulley selectively engaged to the compressor shaft by a first electric clutch or by a second power source via a second compressor-shaft-mounted pulley. In this embodiment, both pulleys are
30 mounted on the same end outside of the compressor end bell/front housing.

Figure 1B depicts an embodiment of a the compressor end bell/front housing for the compressor depicted in **Figure 1A**, including the "neck" through which the compressor shaft

is mounted and a “needle bearing” used to support the compressor shaft, which is used to support each pulley.

Figure 1C depicts a front view of an embodiment of a compressor end bell/front housing for the compressor depicted in **Figure 1B**, with “needle bearing” installed in the “neck”.

Figure 1D depicts one embodiment of an outer hub used to mount the second (outer) pulley shown in **Figure 1A**.

Figure 1E depicts one embodiment of an outer hub of **Figure 1D** with the second (outer) pulley shown installed on it.

Figure 2 depicts one embodiment of a system diagram for a dual-power-mode automobile air-conditioning system using a modified compressor.

Figure 3 depicts an embodiment of an automobile air-conditioning system refrigerant compressor that is adapted to be driven either by the vehicle engine via a pulley selectively engaged to the compressor shaft by a first electric clutch or by a second power source via a second compressor-shaft-mounted pulley. In this embodiment, each pulley is mounted on the opposite end outside of the respective compressor end bell/housing, with respect to the other pulley.

Figure 4 depicts one embodiment of a modified compressor shaft used to mount two pulleys on opposite ends, with respect to each other, as shown in the compressor in **Figure 3**.

The drawing in this figure is not to scale and the dimensions shown are exemplary only.

Figure 5 depicts an alternate embodiment of a system diagram for a dual-power-mode automobile air-conditioning system modified compressor, as opposed to the embodiment depicted in **Figure 2**.

Figure 6 depicts one embodiment of a process flow diagram for a compressor-based automobile air-conditioning system, and specifically addresses the system’s management of the energy sources for the DC power supplied to the DC motor when it drives the compressor.

Figure 7 depicts one embodiment of a system diagram of an air-conditioning system that employs at least one thermal-electric cooler (TEC) module instead of a vapor-compression system.

Figures 8A depicts one embodiment of a process flow diagram for a TEC-based automobile air-conditioning system, and specifically addresses the system’s management of

Figures 8B depicts one embodiment of a process flow diagram for a user or system setting of a target operating ambient temperature.

Figure 8C depicts one embodiment of the process an embodiment of the TEC-based air-conditioning system goes through to store thermal energy for cooling and heating purposes.

Figure 9 depicts one embodiment of a control-system process used to manage the operation of an automobile air-conditioning system that employs both a modified-compressor-based system and a TEC-based system.

DETAILED DESCRIPTION

I. Overview

The present inventive disclosure is directed generally to an improved automobile air-conditioning system that can be operated while the automobile's engine is not running. In one embodiment, a typical vapor-compression-cycle air-conditioning system is modified to allow the refrigerant compressor to be driven from either of two power sources: (1) from a traditional engine-mounted pulley system, or (2) from a DC motor powered by an electrical source independent from the engine, wherein the DC motor drives a secondary pulley mounted on the refrigerant compressor. In a different embodiment, the air-conditioning system is driven by one or more thermal-electric-cooling (TEC) modules that employ the Peltier Effect, wherein the TEC-based system is powered by an auxiliary DC power source that in some variations is powered by, or at least supplemented by, a solar-energy grid. In yet another embodiment, a modified automobile air-conditioning system comprises both the modified-compressor-based system and the TEC-based system, wherein the compressor-based system is used to initially cool-down an automobile passenger compartment, then is shutdown in favor of the TEC-based system to maintain the attained ambient temperature.

In an embodiment, the refrigerant compressor has a standard primary pulley that is configured to be driven by an automobile engine, said primary pulley engaged by way of an electric clutch commonly found in virtually all automobile air-condition systems. However, the compressor is also equipped with a secondary pulley that is directly coupled to the compressor shaft. This secondary pulley driven by a DC-powered motor via a third pulley and belt assembly, the third pulley coupled to the shaft of the DC motor via a second electric clutch assembly, and the DC-powered motor has a power source independent of the engine. Typically, this independent power source is a combination of an auxiliary battery and a solar-

cell grid. In variations, there is a control-system interlock to prevent simultaneous engagement of both clutch-pulley assemblies so that the compressor is only powered from one source at a time. In other variations, the compressor has a modified shaft adapted to have the primary and secondary clutch-pulley assemblies mounted on opposite ends of the compressor. In still more variations, the modified shaft of the compressor is adapted to have the primary and secondary pulley assemblies on the same end of the compressor housing.

The air-conditioning system is configured to allow the refrigerant compressor, and/or the TEC-based modules, depending on the embodiment, to drive the air-conditioning system processes even though the engine is turned off, with the goal to allow for pre-cooling of a passenger compartment before actual engine operations are conducted. In an embodiment, the air-conditioning system is remotely activated while the engine is off, and is powered by an auxiliary battery, augmented by a solar-power grid that also serves to help keep the auxiliary battery charged. In this mode, in an embodiment, the air-conditioning system can run for 15-30 minutes to pre-cool the automobile's passenger compartment before having to turn on the engine to activate the primary air-conditioning power source.

In additional embodiments, the remote activation employs keyless technologies known in the art. In other variations, users can remotely activate the DC-powered mode of the air-conditioning system via a smart-phone application where the target automobile is enabled to receive mobile communications.

II. Terminology

The terms and phrases as indicated in quotes (“ ”) in this section are intended to have the meaning ascribed to them in this Terminology section applied to them throughout this document, including the claims, unless clearly indicated otherwise in context. Further, as applicable, the stated definitions are to apply, regardless of the word or phrase's case, to the singular and plural variations of the defined word or phrase.

The term “or”, as used in this specification and the appended claims, is not meant to be exclusive; rather, the term is inclusive, meaning “either or both”.

References in the specification to “one embodiment”, “an embodiment”, “a preferred embodiment”, “an alternative embodiment”, “a variation”, “one variation”, and similar phrases mean that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least an embodiment of the invention. The appearances of the phrase “in one embodiment” and/or “in one variation” in various places in the specification are not necessarily all meant to refer to the same embodiment.

The term “couple” or “coupled”, as used in this specification and the appended claims, refers to either an indirect or a direct connection between the identified elements, components, or objects. Often, the manner of the coupling will be related specifically to the manner in which the two coupled elements interact.

5 The term “removable”, “removably coupled”, “readily removable”, “readily detachable”, “detachably coupled”, and similar terms, as used in this patent application specification (including the claims and drawings), refer to structures that can be uncoupled from an adjoining structure with relative ease (i.e., non-destructively, and without a complicated or time-consuming process) and that can also be readily reattached or coupled to
10 the previously adjoining structure.

Directional and/or relational terms such as, but not limited to, left, right, nadir, apex, top, bottom, vertical, horizontal, back, front, and lateral are relative to each other, are dependent on the specific orientation of an applicable element or article, are used accordingly to aid in the description of the various embodiments in this specification and the appended
15 claims, and are not necessarily intended to be construed as limiting.

As applicable, the terms “about” or “generally”, as used herein in the specification and appended claims, and unless otherwise indicated, means a margin of $\pm 20\%$. Also, as applicable, the term “substantially” as used herein in the specification and appended claims, unless otherwise indicated, means a margin of $\pm 10\%$. It is to be appreciated that not all uses
20 of the above terms are quantifiable such that the referenced ranges can be applied.

III. A Dual-Power-Source Compressor-Based Automobile Air-Conditioning System

This embodiment is directed generally to a vapor-compressor-based air-conditioning system for an automobile, featuring a specially modified air-conditioning compressor adapted to be driven from either of two different power sources.

25 Refer to **Figures 1A-6**. In an embodiment, the air-conditioning system comprises a specially modified vapor compressor **1**, which in variations can take one of two main forms, as discussed below. In some embodiments, the refrigerant compressor **1**, has a first housing end bell **2**, a second housing end bell **7**, an inlet and an outlet for transporting refrigerant, and a central drive shaft **19** that when turned with rotational force causes the compressor **1** to
30 compress refrigerant gasses contained therein. Further, the system has a first compressor-driving pulley **4** adapted to facilitate the rotational driving of the compressor **1** via the use of a pulley belt driven by an automobile engine. In one variation, the compressor **1** is engaged to the first compressor-driving pulley **4** by a first electric clutch assembly **3** adapted to

facilitate the selective coupling of the first pulley **4** with the central drive shaft **19**, when the electric clutch assembly **3** is energized. In another variation, the system has a second compressor-driving pulley **5A, 5B** directly coupled to said central drive shaft to facilitate the rotational driving of the compressor **1** via a pulley belt driven by a power source that does not
5 rely on the running of an automobile engine.

In another embodiment, to facilitate the driving of the compressor **1** from a secondary power source, the system has an electrical motor **12** adapted to be able to drive the refrigerant compressor **1** via a pulley system **11**, wherein said electrical motor is adapted to be powered from an independent DC power source that does not depend on the running of the engine of
10 said automobile. In variations, the shaft of the electrical motor **12** is adapted to drive a third pulley **11** mounted at one end of the housing of the electrical motor **12**, the third pulley **11** coupled to the second compressor-driving pulley **5A, 5B** via a pulley belt, and the electrical motor **12** is adapted to have a second electric clutch assembly **6A, 10** to allow the selective coupling of the electrical motor's **12** shaft and the third pulley **11**, depending on whether the
15 electric clutch assembly is energized. The electric clutches **3, 6A** used are of the type currently well-known in the art in automobile air-conditioning systems.

In still more embodiments, the system has an evaporator for transferring heat from the passenger compartment air of the automobile to the refrigerant circulated within the evaporator, as is the case with a typical compressor-based automobile air-conditioning
20 system. Similarly, the system has at least one electric passenger-compartment cooling fan **13** for circulating air around the evaporator, a condenser for transferring heat from refrigerant to the outside atmosphere, and at least one electric heat-sink fan **13** for circulating outside air around the condenser **1**.

In yet more embodiments, the system includes an independent DC electrical system;
25 that is, independent of the automobile's engine electrical system; comprised of:

- at least one battery **18** (typically rated at approximately 12 VDC or 24 VDC) for providing power to the air-conditioning system when the automobile engine is shutdown;
- a solar-energy grid **17** adapted to be mounted at one or more surfaces and/or
30 windows of the automobile to ensure solar exposure for producing electrical power, and adapted to provide a trickle charge to the at least one battery **18**; and
- a programmable controller module **14, 15, 600** adapted to monitor the voltage level of the at least one battery **18**, the passenger-compartment ambient

temperature, and the operating status of the automobile, wherein:

- The programmable controller module **14, 15, 600** is further adapted to start the air-conditioning system and set the power mode for the air-conditioning system, and
- 5 ○ The programmable controller module **14, 15, 600** is adapted to prevent the simultaneous engagement of the first and second electric clutches **3, 6A**.

The ratings/sizes of the various components of the DC motor **12** and independent DC electrical system (e.g., battery **18**, solar-energy grid **17**) can vary with the application. The available surface area for the installation of solar-energy grid panels **17**, for example, will
10 affect the necessary efficiency and power ratings of the solar-energy grid panels **17** used, and thus the number of solar-energy grid panels **17** used. In some embodiments, the solar-energy grid **17** may only have enough capacity to supplement the battery **18** when powering the air-conditioning system, and otherwise recharge the battery **18** when not powering the air-conditioning system. In one example embodiment, the solar-energy grid **17** is wafer-thin
15 (< 1/4 inch thick), is capable of producing power in even cloudy conditions, is rated for at least 4500-7500 Watts, and is sized such that it is capable of charging the battery **18** at approximately 1% of the battery's **18** rated capacity. In the case of the battery **18** and DC motor **12**, in one embodiment, the DC motor rating (which will determine the selected battery size) is 12-24 VDC, 2.5-3.5 HP, 2500-3500 rpm, and weighs approximately 10 lbs or less.

20 In some variations, the first compressor-driving pulley **4** is adapted to receive a pulley belt of a type selected from the group including serpentine, V-belt, V-link, and/or flat. Similarly, in other variations, the second compressor-driving pulley **5A, 5B** is adapted to receive a pulley belt of a type selected from the group including serpentine, V-belt, V-link, and/or flat.

25 In one version of the system's modified compressor **1**, the first and second compressor-driving pulleys **4, 5A** are mounted on the same side of the central drive shaft **19**, the electric clutch assembly **3, 6A** is equipped with an outer hub **10** at which the first compressor-driving pulley **4** is adapted to be selectively coupled to the central drive shaft **19**, and the second compressor-driving pulley **5B** is directly coupled to the central drive shaft via
30 the neck **8** of the outer hub, onto which is installed an additional roller bearing **9**.

In an another version of the system's modified compressor **1**, the first and second compressor-driving pulleys **4, 5B** on opposite sides of said central drive shaft **19** with respect to each other, the central drive shaft **19** is modified to extend beyond the compressor housing

end bell **7** in order to support one of the first and second pulleys **4, 5B** at each end of the compressor **1**. In similar variations, each of the first and second housing end bells **2, 7** are substantially structurally identical, and each has a bearing adapted to support the central drive shaft **19**, with each end having packing seals for inhibiting the leakage of either lubricants or refrigerant. In yet another variation on this, at one end of the compressor **1**, the electric clutch assembly **3** is equipped with an outer hub **6B** at which the first compressor-driving pulley **4** is adapted to be selectively coupled to the central drive shaft **19**; and at the other end of the compressor **1**, the second compressor-driving pulley **5B** is directly coupled to the compressor's drive shaft **19** via the neck of respective housing end bell **7**, onto which is installed an additional roller bearing **9**.

In many embodiments, the power mode set by the programmable controller module **14, 15, 600** is selected from the group including the following options: powered by the engine, powered by the independent DC electrical system using the battery **18**, and/or recharging mode of said battery from the solar-energy grid **17**.

In more embodiments, the programmable controller module **14, 15, 600** comprises a computer-readable medium containing programmed instructions that cause the independent DC electrical system to energize the second electric clutch **6A**, the electrical motor **12**, the at least one passenger-compartment fan **13**, and the at least one heat-sink fan **13** to energize and activate the air-conditioning system at a pre-determined day and time, for a pre-determined interval, while the automobile engine is not running.

In yet another variation, the programmable controller module **14, 15, 600** comprises a computer-readable medium containing programmed instructions that cause the powering of the air-conditioning system to emanate from the independent DC electrical system while disengaging the first electric clutch **4** when the automobile slows to a predetermined speed or less (for example, 10 mph or less).

In still other variations, the programmable controller module **14, 15, 600** comprises a computer-readable medium containing programmed instructions that cause the powering of the air-conditioning system to emanate from the independent DC electrical system while disengaging the first electric clutch **4** when the automobile is at a standstill while the automobile engine is running and the automobile's transmission is in a park or neutral state.

In more embodiments, the programmable controller module **14, 15, 600** is adapted for wireless communication in order to enable remote-control operations by a user such that the air-conditioning system can be remotely started and stopped by a user using a remote keyless device and/or a mobile application on a wireless communications device.

In an exemplary embodiment, power-management by the programmable controller module **600** (see **Figure 6**) follows the following steps:

- Determine the primary energy source state; e.g., is the automobile running, and what is the state of charge of the battery **18**? **605**
- 5 • Determine whether to run a preprogrammed (user-defined) mode or an automatic mode. **610**
- If in preprogrammed mode, then:
 - Activate at the programmed time. **615**
 - Run the system for the programmed time. **620**
 - 10 ○ Set the fan speed; automobile climate. **625**
 - Set the climate-control unit temperature. **630**
- If in automatic mode, then:
 - Engage the alternative DC electrical power system in lieu of the engine when the car is ≤ 10 mph, has been idle or stopped for ≥ 2 minutes, OR the engine is running and the vehicle transmission is in Park (P) or Neutral (N). **635**
 - 15 ○ Determine whether the primary energy source (e.g., battery **18**) is below an allowable/predetermined threshold. **640**
 - If NO, then:
 - Open the circuit between the solar-energy grid **17** and the primary energy source time. **645**
 - 20 ○ Close the circuit between the primary energy source **18** and the DC motor **12**. **650**
 - Open the circuit between the solar-energy grid **17** and the DC motor **12**. **655**
 - END. **685**
 - 25 • If YES, then:
 - Close the circuit between the solar-energy grid **17** and the DC motor **12**. **660**
 - Open the circuit between the primary energy source **18** and the DC motor **12**. **665**
 - Close the circuit between the solar-energy grid **17** and the primary energy

source **18. 670**

- Recharge the primary energy source **18. 675**
- Determine whether primary energy source **18** is back above threshold. **680**
- If NO, then repeat these recharge steps.
- 5 ○ If YES, then END. **685**

IV. A Dual-Power-Source Thermal-Electric-Cooler-Based Automobile Air-Conditioning System

This embodiment is directed generally to a thermal-electric-cooler (TEC) based air-conditioning system for an automobile, featuring the use of devices that employ the Peltier
 10 Effect as current passes through a junction of dissimilar materials, and which is adapted to be powered from either of two different power sources.

Refer to **Figures 7-8C**. In an embodiment, the air-conditioning system comprises a thermal-electric cooler (TEC) module **24**, having one or more Peltier junctions, and a thermal-energy-storage (TES) unit **23** comprised of at least one low-pressure container
 15 containing a non-reactive filler material, wherein the non-reactive filler material is adapted to absorb heat and melt above a predetermined threshold, and conversely is adapted to release stored heat and freeze at a predetermined threshold. In addition, in variations, the system has one or more forced-air-circulation devices **19, 21, 22** for circulating ambient air between the passenger compartment of an automobile, and the TEC module **24** and TES unit **23**.

In summary, this TEC-based system uses sensible heat to store energy in and extract energy from the TES **23**. The non-reactive filler material in the TES **23** is arranged such that the maximum heat transfer is achieved with minimal pressure drop between the TES **23** air-inlet pressure and the outlet pressure. The transition temperature for the filler material in the TES **23** is controlled so that it melts and freezes at an established baseline temperature (T_{BL}),
 25 typically about 21.1°C (70°F). In an embodiment, the ambient temperature (T_{AMB}) detector communicates its readings to a programmable controller module **14, 15, 800**. For heating, the ambient temperature is compared to the baseline temperature (T_{BL}). The temperature of the filler material (measured by detector **25**) is compared to 0°C (32°F) (T_{STAT}). If $T_{AMB} < T_{BL}$, and the TES filler-material temperature is < 0°C (32°F), then the TES filler material will
 30 begin to freeze as it gives off heat. Conversely, for cooling, the ambient temperature is also compared to the baseline temperature (T_{BL}). Similarly, the temperature of the filler material (measured by detector **25**) is compared to 0°C (32°F) (T_{STAT}). If $T_{AMB} \geq T_{BL}$, then the TES filler material will begin to melt as it absorbs heat. These temperatures are continuously

monitored for purposes of “recharging” the TES filler material in order to facilitate later cooling/heating.

In yet more embodiments, the system includes an independent DC electrical system; that is, independent of the automobile’s engine electrical system; comprised of:

- at least one battery **18** (typically rated at approximately 12 VDC or 24 VDC) for providing power to the air-conditioning system when the automobile engine is shutdown;
- a solar-energy grid **17** adapted to be mounted at one or more surfaces and/or windows of the automobile to ensure solar exposure for producing electrical power, and adapted to provide a trickle charge to the at least one battery **18**; and
- a programmable controller module **14, 15, 800** adapted to monitor the voltage level of the at least one battery **18**, the passenger-compartment ambient temperature **26**, and the operating status of the automobile, wherein:
 - The programmable controller module **14, 15, 800** is further adapted to start the air-conditioning system and set the power mode for the air-conditioning system. Typically, the system manipulations include the opening or closing of one or more solenoid valves **20**. In a variation, the solenoid valve **20** is a two-port, two-position solenoid valve.

In a variation, the non-reactive filler material in the TES **23** may be selected from the group including Silicon Nitride, Silicon Carbide, Titanium Diboride, Aluminum Oxide, and/or Mullite.

In many embodiments, the power mode set by the programmable controller module **14, 15, 800** is selected from the group including the following options: powered by the engine, powered by the independent DC electrical system using the battery **18**, and/or recharging mode of said battery from the solar-energy grid **17**.

In another variation, the programmable controller module **14, 15, 800** comprises a computer-readable medium containing programmed instructions that cause the independent DC electrical system to energize the one or more passenger-compartment forced-air circulation devices **19, 21, 22** and activate the air-conditioning system at a pre-determined day and time, for a pre-determined interval, while said automobile engine is not running.

In yet another variation, the programmable controller module **14, 15, 800** comprises a computer-readable medium containing programmed instructions that cause the powering of

the air-conditioning system to emanate from the independent DC electrical system instead of said automobile's engine electrical system when said automobile slows to a predetermined speed or less (for example, 10 mph or less).

In still other variations, the programmable controller module **14, 15, 800** comprises a computer-readable medium containing programmed instructions that cause the powering of the air-conditioning system to emanate from the independent DC electrical system instead of the automobile's engine electrical system when the automobile is at a standstill while the automobile engine is running and the automobile's transmission is in a park or neutral state.

In more embodiments, the programmable controller module **14, 15, 800** is adapted for wireless communication in order to enable remote-control operations by a user such that the air-conditioning system can be remotely started and stopped by a user using a remote keyless device and/or a mobile application on a wireless communications device.

In an exemplary embodiment, power-management by the programmable controller module **800** (see **Figures 8A-8C**) follows the following steps:

- Determine the primary energy source state; e.g., is the automobile running, and what is the state of charge of the battery **18? 805**
- Determine whether to run a preprogrammed (user-defined) mode or an automatic mode. **810**
- If in preprogrammed mode, then:
 - Activate at the programmed time. **815**
 - Run the system for the programmed time. **820**
 - Set the fan speed; automobile climate. **825**
 - Set the climate-control unit temperature. **830**
- If in automatic mode, then:
 - Engage the alternative DC electrical power system in lieu of the engine when the car is ≤ 10 mph, has been idle or stopped for ≥ 2 minutes, OR the engine is running and the vehicle transmission is in Park (P) or Neutral (N). **835**
 - Determine whether the primary energy source (e.g., battery **18**) is below an allowable/predetermined threshold. **840**
 - If NO, then:
 - Open the circuit between the solar-energy grid **17** and the primary energy

source. **845**

- Close the circuit between the primary energy source **18** and the TEC unit **24**. **850**
- Open the circuit between the solar-energy grid **17** and the TEC unit **24**. **855**
- 5 ○ END. **885**
- If YES, then:
 - Close the circuit between the solar-energy grid **17** and the TEC unit **24**. **860**
 - Open the circuit between the primary energy source **18** and the TEC unit **24**. **865**
 - 10 ○ Close the circuit between the solar-energy grid **17** and the primary energy source **18**. **870**
 - Recharge the primary energy source **18**. **875**
 - Determine whether primary energy source **18** is back above threshold. **880**
 - If NO, then repeat these recharge steps.
 - 15 ○ If YES, then CONTINUE. **885**
- Start cooling/heating system setting. **802**
- User-defined setting?
- If YES, then:
 - For cooling (cool ambient, $T_{AMB} \leq T_{BL}$; or hot ambient, $T_{AMB} \geq T_{BL}$), the
20 controller **14, 15, 800** energizes N-type semi-conductor pellets; starts heat-injection process [melting the phase-change materials (PCM)]. **808**
 - For heating (cool ambient, $T_{AMB} \leq T_{BL}$; or hot ambient, $T_{AMB} \geq T_{BL}$), the controller **14, 15, 800** energizes P-type semi-conductor pellets; starts heat-extraction process [freezing the phase-change materials (PCM)]. **812**
 - 25 • If NO, then determine if $T_{AMB} \geq T_{BL}$. **806**
 - If YES, then for cooling (hot ambient, $T_{AMB} \geq T_{BL}$), the controller **14, 15, 800** energizes N-type semi-conductor pellets; starts heat-injection process [melting the phase-change materials (PCM)]. **814**
 - If NO, then for heating (cool ambient, $T_{AMB} \leq T_{BL}$), the controller **14, 15, 800**

energizes P-type semi-conductor pellets; starts heat-extraction process

[freezing the phase-change materials (PCM)]. **816**

- Determine temperature of TES (T_{TES}). **803**

- If heating mode, then:

5 ○ If $T_{TES} \leq$ Freezing Point **806**, then:

- Energize N-type semi-conductor pellets; **818** and
- Start heat-injection process [melting the phase-change materials (PCM)]. **818**

○ If $T_{TES} >$ Freezing Point, then:

- 10 ▪ Maintain current to P-type semi-conductor pellets; **821** and
- Maintain heat-extraction process [freezing the phase-change materials (PCM)]. **821**

- If cooling mode, then:

○ If $T_{TES} \geq$ Melting Point **809**, then:

- 15 ▪ Energize P-type semi-conductor pellets; **824** and
- Start heat-extraction process [freezing the phase-change materials (PCM)]. **824**

○ If $T_{TES} >$ Freezing Point, then:

- 20 ▪ Maintain current to N-type semi-conductor pellets; **827** and
- Maintain heat-injection process [freezing the phase-change materials (PCM)]. **827**

- Determine if PCM fully recharged. **833**

- If NO, then go to **818** (for heating mode) or **824** (for cooling mode).

- Resume execution of previously selected program mode(s). **839**

25 • END. **842**

V. A Dual-Power-Source, Dual-Mode Automobile Air-Conditioning System

This embodiment is directed generally to an air-conditioning system for an automobile that can be powered from multiple power sources and can operate via either of

two operating modes: One operating mode is a vapor-compression-based air-conditioning system, and the other operating mode is a thermal-electric-cooling (TEC) based air-conditioning system. The general goal of this system is to allow a user to cool an automobile's passenger compartment with the engine turned off by first running the compressor-based system via a DC motor long enough to obtain a desired predetermined passenger compartment temperature, then there after switching the operating mode to the TEC-based system to maintain the temperature within a predetermined range. This is because some TEC designs are not ideal for providing for quick and efficient cool-down over a large range, but are more suited for helping to maintain a target temperature once the system has been "primed" with an initially cooled-down environment.

Refer to **Figures 1A-10**. This embodiment basically incorporates both the disclosures in Section III and Section IV, discussed *supra*. The key addition is a modified programmable controller that not only performs the processes defined in **Figures 6 and 8A-8C**, as well as **Sections III and IV**, but also controls the operating mode of the overall air-conditioning system; that is, switches between the compressor-based subsystem and the TEC-based subsystem. In addition, in some embodiments, a user can manually select the operating mode of the air-conditioning system.

In an exemplary embodiment, the operating-mode-management by the programmable controller module **900** (see **Figure 9**) follows the following steps:

- Determine the passenger compartment ambient temperature (T_{AMB}) **905**
- Determine whether T_{AMB} is above user-defined or preprogrammed setpoint. **905**
- If NO, then stop. **950**
- If YES, then determine if $T_{AMB} >$ user-defined or preprogrammed setpoint above the tolerance threshold (e.g., 10°F or other user-defined or programmed tolerance range). **910**
- If YES, then: **910**
 - Activate the compressor-based subsystem. **915**
 - Manage power to the compressor-based subsystem according to **Section III** and **Figure 6**. **920**
 - If T_{AMB} cools to within the tolerance threshold, then: **925**
 - Shutdown the compressor-based system **930**, and

- Activate TEC-based subsystem. **935**

- If NO, then: **910**
 - Activate the TEC-based subsystem. **935**
 - Manage power to the TEC-based subsystem according to **Section IV** and

5 **Figures 8A-8C. 940**

- END. **945**

10 In more embodiments, the programmable controller module **14, 15, 900** is adapted for wireless communication in order to enable remote-control operations by a user such that the air-conditioning system can be remotely started and stopped, and employs the process outlined above by a user using a remote keyless device and/or a mobile application on a wireless communications device.

VI. Alternative Embodiments and Other Variations

15 The various embodiments and variations thereof described herein and/or illustrated in the accompanying Figures are merely exemplary and are not meant to limit the scope of the inventive disclosure. It should be appreciated that numerous variations of the invention have been contemplated as would be obvious to one of ordinary skill in the art with the benefit of this disclosure.

20 Hence, those ordinarily skilled in the art will have no difficulty devising myriad obvious variations and improvements to the invention, all of which are intended to be encompassed within the scope of the claims which follow.

CLAIMS

What is claimed is:

1. A modified air-conditioning compressor used for a motorized vehicle, said modified
5 compressor comprising:

a refrigerant compressor,

said refrigerant compressor having a first housing end bell,

said refrigerant compressor having a second housing end bell,

said refrigerant compressor having an inlet and an outlet for transporting
10 refrigerant, and

said refrigerant compressor having a central drive shaft that when turned with
rotational force causes said compressor to compress refrigerant gasses contained
therein;

a first compressor-driving pulley adapted to facilitate the rotational driving of said
15 compressor from a first power source via the use of a pulley belt;

an electric clutch assembly adapted to facilitate the selective coupling of said first
pulley with said central drive shaft, when said electric clutch assembly is energized; and

a second compressor-driving pulley directly coupled to said central drive shaft to
facilitate the rotational driving of said compressor from a second power source via the
20 use of a pulley belt.

2. The compressor of claim 1, wherein:

said first and second compressor-driving pulleys are mounted on the same end of said
central drive shaft;

said electric clutch assembly is equipped with an outer hub at which said first
25 compressor-driving pulley is adapted to be selectively coupled to said central drive
shaft;

said second compressor-driving pulley is directly coupled to said central drive shaft via
the neck of said outer hub, onto which is installed an additional roller bearing.

3. The compressor of claim 1, wherein:

30 said first and second compressor-driving pulleys are mounted on opposite ends of said

central drive shaft with respect to each other;

said central drive shaft is modified to extend beyond each compressor housing end bell in order to support one of said first and second pulleys at each end of said compressor;

each of said first and second housing end bells are substantially structurally identical,

5 each having a bearing adapted to support said central drive shaft and each having packing seals for inhibiting the leakage of either lubricants or refrigerant;

at one end of said compressor, said electric clutch assembly is equipped with an outer hub at which said first compressor-driving pulley is adapted to be selectively coupled to said central drive shaft; and

10 at the other end of said compressor, said second compressor-driving pulley is directly coupled to said compressor's drive shaft via the neck of respective housing end bell, onto which is installed an additional roller bearing.

4. The compressor of claim 1, wherein:

15 said first compressor-driving pulley is adapted to receive a pulley belt of a type selected from the group consisting of serpentine, V-belt, V-link, and flat; and

said second compressor-driving pulley is adapted to receive a pulley belt of a type selected from the group consisting of serpentine, V-belt, V-link, and flat.

5. A method of making a modified air-conditioning compressor used for a motorized vehicle, said method the steps of:

20 providing a refrigerant compressor,

said refrigerant compressor having a first housing end bell,

said refrigerant compressor having a second housing end bell,

said refrigerant compressor having an inlet and an outlet for transporting refrigerant, and

25 said refrigerant compressor having a central drive shaft that when turned with rotational force causes said compressor to compress refrigerant gasses contained therein;

providing a first compressor-driving pulley adapted to facilitate the rotational driving of said compressor from a first power source via the use of a pulley belt;

30 providing an electric clutch assembly adapted to facilitate the selective coupling of said

first pulley with said central drive shaft, when said electric clutch assembly is energized; and

providing a second compressor-driving pulley directly coupled to said central drive shaft to facilitate the rotational driving of said compressor from a second power source via the use of a pulley belt.

6. The method of claim 5, further comprising the steps of:

mounting said first and second compressor-driving pulleys on the same end of said central drive shaft;

equipping said electric clutch assembly with an outer hub at which said first compressor-driving pulley is adapted to be selectively coupled to said central drive shaft;

coupling said second compressor-driving pulley is directly to said central drive shaft via the neck of said outer hub, onto which is installed an additional roller bearing.

7. The method of claim 5, further comprising the steps of:

modifying said central drive shaft to extend beyond each compressor housing end bell in order to support one of said first and second pulleys at each end of said compressor; mounting said first and second compressor-driving pulleys on opposite ends of said central drive shaft with respect to each other;

providing said first and second housing end bells that are substantially structurally identical to each other, each having a bearing adapted to support said central drive shaft and each having packing seals for inhibiting the leakage of either lubricants or refrigerant;

at one end of said compressor, equipping said electric clutch assembly with an outer hub at which said first compressor-driving pulley is adapted to be selectively coupled to said central drive shaft; and

at the other end of said compressor, directly coupling said second compressor-driving pulley to said compressor's drive shaft via the neck of respective housing end bell, onto which is installed an additional roller bearing.

8. The method of claim 5, wherein:

said first compressor-driving pulley is adapted to receive a pulley belt of a type selected from the group consisting of serpentine, V-belt, V-link, and flat; and

said second compressor-driving pulley is adapted to receive a pulley belt of a type selected from the group consisting of serpentine, V-belt, V-link, and flat.

9. An air-conditioning system for an automobile, said automobile having an engine, said air-conditioning system comprising:

5 a refrigerant compressor,

said refrigerant compressor having a first housing end bell,

said refrigerant compressor having a second housing end bell,

said refrigerant compressor having an inlet and an outlet for transporting refrigerant, and

10 said refrigerant compressor having a central drive shaft that when turned with rotational force causes said compressor to compress refrigerant gasses contained therein;

a first compressor-driving pulley adapted to facilitate the rotational driving of said compressor via the use of a pulley belt driven by said automobile engine;

15 a first electric clutch assembly adapted to facilitate the selective coupling of said first pulley with said central drive shaft, when said electric clutch assembly is energized;

a second compressor-driving pulley directly coupled to said central drive shaft to facilitate the rotational driving of said compressor via a pulley belt driven by a power source that does not rely on the running of said automobile engine;

20 an electrical motor adapted to be able to drive said refrigerant compressor via a pulley system,

wherein said electrical motor is adapted to be powered from an independent DC power source that does not depend on the running of the engine of said automobile,

25 wherein the shaft of said electrical motor is adapted to drive a third pulley mounted at one end of the housing of said electrical motor, said third pulley coupled to said second compressor-driving pulley via a pulley belt, and

wherein said electrical motor is adapted to have a second electric clutch assembly to allow the selective coupling of said electrical motor's shaft and said third

30 pulley, depending on whether said electric clutch assembly is energized;

an evaporator for transferring heat from the passenger compartment air of said

automobile to said refrigerant circulated within said evaporator;

at least one electric passenger-compartment cooling fan for circulating air around said evaporator;

a condenser for transferring heat from refrigerant to the outside atmosphere;

- 5 at least one electric heat-sink fan for circulating outside air around said condenser; and
an independent DC electrical system, independent of said automobile's engine electrical system, comprised of:

at least one battery for providing power to said air-conditioning system when said automobile engine is shutdown,

- 10 a solar-energy grid, said solar-energy grid adapted to be mounted at one or more surfaces and/or windows of said automobile to ensure solar exposure for producing electrical power, said solar-energy grid adapted to provide a trickle charge to said at least one battery, and

- 15 a programmable controller module, said controller module adapted to monitor the voltage level of said at least one battery, the passenger-compartment ambient temperature, and the operating status of said automobile,

wherein said programmable controller module is further adapted to start said air-conditioning system and set the power mode for said air-conditioning system, and

- 20 wherein said programmable controller module is adapted to prevent the simultaneous engagement of said first and second electric clutches.

10. The system of claim 9, wherein:

said first compressor-driving pulley is adapted to receive a pulley belt of a type selected from the group consisting of serpentine, V-belt, V-link, and flat; and

- 25 said second compressor-driving pulley is adapted to receive a pulley belt of a type selected from the group consisting of serpentine, V-belt, V-link, and flat.

11. The system of claim 9, wherein:

said first and second compressor-driving pulleys are mounted on the same end of said central drive shaft;

- 30 said electric clutch assembly is equipped with an outer hub at which said first

compressor-driving pulley is adapted to be selectively coupled to said central drive shaft; and

said second compressor-driving pulley is directly coupled to said central drive shaft via the neck of said outer hub, onto which is installed an additional roller bearing.

5 12. The system of claim 9, wherein:

said first and second compressor-driving pulleys are mounted on opposite ends of said central drive shaft with respect to each other;

said central drive shaft is modified to extend beyond each compressor housing end bell in order to support one of said first and second pulleys at each end of said compressor;

10 each of said first and second housing end bells are substantially structurally identical, each having a bearing adapted to support said central drive shaft and each having packing seals for inhibiting the leakage of either lubricants or refrigerant;

at one end of said compressor, said electric clutch assembly is equipped with an outer hub at which said first compressor-driving pulley is adapted to be selectively coupled to
15 said central drive shaft; and

at the other end of said compressor, said second compressor-driving pulley is directly coupled to said compressor's drive shaft via the neck of respective housing end bell, onto which is installed an additional roller bearing.

13. The system of claim 9, wherein said power mode set by said programmable controller
20 module is selected from the group consisting of powered by said engine, powered by said independent DC electrical system using said battery, and recharging mode of said battery from said solar-energy grid.

14. The system of claim 9, wherein said programmable controller module comprises a
25 computer-readable medium, said computer-readable medium containing programmed instructions that cause said independent DC electrical system to energize said second electric clutch, said electrical motor, said at least one passenger-compartment fan, and said at least one heat-sink fan to energize and activate said air-conditioning system at a pre-determined day and time, for a pre-determined interval, while said automobile engine is not running.

30 15. The system of claim 9, wherein said programmable controller module comprises a computer-readable medium, said computer-readable medium containing programmed

instructions that cause the powering of said air-conditioning system to emanate from said independent DC electrical system while disengaging said first electric clutch when said automobile slows to a predetermined speed or less.

16. The system of claim 9, wherein said programmable controller module comprises a computer-readable medium, said computer-readable medium containing programmed instructions that cause the powering of said air-conditioning system to emanate from said independent DC electrical system while disengaging said first electric clutch when said automobile is at a standstill while said automobile engine is running and said automobile's transmission is in a park or neutral state.

17. The system of claim 9, wherein:

said programmable controller module is adapted for wireless communication in order to enable remote-control operations by a user; and

said air-conditioning system can be remotely started and stopped by a user using a remote keyless device.

18. The system of claim 9, wherein:

said programmable controller module is adapted for wireless communication in order to enable remote-control operations by a user; and

said air-conditioning system can be remotely started and stopped by a user using a mobile application on a wireless communications device.

19. A method of making an air-conditioning system for an automobile, said automobile having an engine, said method comprising the steps of:

providing a refrigerant compressor,

said refrigerant compressor having a first housing end bell,

said refrigerant compressor having a second housing end bell,

said refrigerant compressor having an inlet and an outlet for transporting refrigerant, and

said refrigerant compressor having a central drive shaft that when turned with rotational force causes said compressor to compress refrigerant gasses contained therein;

providing a first compressor-driving pulley adapted to facilitate the rotational driving of

said compressor via the use of a pulley belt driven by said automobile engine;

providing a first electric clutch assembly adapted to facilitate the selective coupling of said first pulley with said central drive shaft, when said electric clutch assembly is energized;

5 providing a second compressor-driving pulley directly coupled to said central drive shaft to facilitate the rotational driving of said compressor via a pulley belt driven by a power source that does not rely on the running of said automobile engine;

providing an electrical motor adapted to be able to drive said refrigerant compressor via a pulley system,

10 wherein said electrical motor is adapted to be powered from an independent DC power source that does not depend on the running of the engine of said automobile,

wherein the shaft of said electrical motor is adapted to drive a third pulley mounted at one end of the housing of said electrical motor, said third pulley
15 coupled to said second compressor-driving pulley via a pulley belt, and

wherein said electrical motor is adapted to have a second electric clutch assembly to allow the selective coupling of said electrical motor's shaft and said third pulley, depending on whether said electric clutch assembly is energized;

providing an evaporator for transferring heat from the passenger compartment air of
20 said automobile to said refrigerant circulated within said evaporator;

providing at least one electric passenger-compartment cooling fan for circulating air around said evaporator;

providing a condenser for transferring heat from refrigerant to the outside atmosphere;

providing at least one electric heat-sink fan for circulating outside air around said
25 condenser; and

providing an independent DC electrical system, independent of said automobile's engine electrical system, comprised of:

at least one battery for providing power to said air-conditioning system when said automobile engine is shutdown,

30 a solar-energy grid, said solar-energy grid adapted to be mounted at one or more of the surfaces and/or windows of said automobile to ensure solar exposure for

producing electrical power, said solar-energy grid adapted to provide a trickle charge to said at least one battery, and

a programmable controller module, said controller module adapted to monitor the voltage level of said at least one battery, the passenger-compartment ambient temperature, and the operating status of said automobile,

wherein said programmable controller module is further adapted to start said air-conditioning system and set the power mode for said air-conditioning system, and

wherein said programmable controller module is adapted to prevent the simultaneous engagement of said first and second electric clutches.

20. The method of claim 19, wherein said power mode set by said programmable controller module is selected from the group consisting of powered by said engine, powered by said independent DC electrical system using said battery, and recharging mode of said battery from said solar-energy grid.

21. The method of claim 19, wherein:

said first compressor-driving pulley is adapted to receive a pulley belt of a type selected from the group consisting of serpentine, V-belt, V-link, and flat; and

said second compressor-driving pulley is adapted to receive a pulley belt of a type selected from the group consisting of serpentine, V-belt, V-link, and flat.

22. The method of claim 19, further comprising the steps of:

mounting said first and second compressor-driving pulleys on the same end of said central drive shaft;

equipping said electric clutch assembly with an outer hub at which said first compressor-driving pulley is adapted to be selectively coupled to said central drive shaft; and

coupling said second compressor-driving pulley is directly to said central drive shaft via the neck of said outer hub, onto which is installed an additional roller bearing.

23. The method of claim 19, further comprising the steps of:

modifying said central drive shaft to extend beyond each compressor housing end bell in order to support one of said first and second pulleys at each end of said compressor;

mounting said first and second compressor-driving pulleys on opposite ends of said central drive shaft with respect to each other;

providing said first and second housing end bells that are substantially structurally identical to each other, each having a bearing adapted to support said central drive shaft and each having packing seals for inhibiting the leakage of either lubricants or refrigerant;

at one end of said compressor, equipping said electric clutch assembly with an outer hub at which said first compressor-driving pulley is adapted to be selectively coupled to said central drive shaft; and

at the other end of said compressor, directly coupling said second compressor-driving pulley to said compressor's drive shaft via the neck of respective housing end bell, onto which is installed an additional roller bearing.

24. The method of claim 19, further comprising the step of providing said programmable controller module with a computer-readable medium, said computer-readable medium containing programmed instructions that cause said independent DC electrical system to energize said second electric clutch, said electrical motor, said at least one passenger-compartment fan, and said at least one heat-sink fan to energize and activate said air-conditioning system at a pre-determined day and time, for a pre-determined interval, while said automobile engine is not running.

25. The method of claim 19, further comprising the step of providing said programmable controller module with a computer-readable medium, said computer-readable medium containing programmed instructions that cause the powering of said air-conditioning system to emanate from said independent DC electrical system while disengaging said first electric clutch when said automobile slows to a predetermined speed or less.

26. The method of claim 19, further comprising the step of providing said programmable controller module with a computer-readable medium, said computer-readable medium containing programmed instructions that cause the powering of said air-conditioning system to emanate from said independent DC electrical system while disengaging said first electric clutch when said automobile is at a standstill while said automobile engine is running and said automobile's transmission is in a park or neutral state.

27. The method claim 19, wherein:

said programmable controller module is adapted for wireless communication in order to

enable remote-control operations by a user; and

said air-conditioning system can be remotely started and stopped by a user using a remote keyless device.

28. The method of claim 19, wherein:

5 said programmable controller module is adapted for wireless communication in order to enable remote-control operations by a user; and

said air-conditioning system can be remotely started and stopped by a user using a mobile application on a wireless communications device.

29. A method of using an air-conditioning system for an automobile according to claim 17,

10 said method comprising the step of:

using a remote keyless device, remotely causing said automobile's air-conditioning system to start.

30. A method of using an air-conditioning system for an automobile according to claim 17,

said method comprising the step of:

15 using a remote keyless device, remotely causing said automobile's air-conditioning system to stop.

31. A method of using an air-conditioning system for an automobile according to claim 18, said method comprising the step of:

20 using a mobile application on a wireless communications device, remotely causing said automobile's air-conditioning system to start.

32. A method of using an air-conditioning system for an automobile according to claim 18, said method comprising the step of:

using a mobile application on a wireless communications device, remotely causing said automobile's air-conditioning system to stop.

25 33. An air-conditioning system for an automobile, comprising:

a thermal-electric cooler (TEC) module, having one or more Peltier junctions;

a thermal-energy-storage (TES) unit comprised of at least one low-pressure container containing a non-reactive filler material,

wherein the non-reactive filler material is adapted to absorb heat and melt above a

predetermined threshold, and conversely is adapted to release stored heat and freeze at a predetermined threshold; and

one or more forced-air-circulation devices for circulating ambient air between the passenger compartment of an automobile, and said TEC module and TES unit.

- 5 34. The system of claim 33, further comprising an independent DC electrical system, independent of said automobile's engine electrical system, said independent DC electrical system comprised of:

at least one battery for providing power to said air-conditioning system when said automobile engine is shutdown,

- 10 a solar-energy grid, said solar-energy grid adapted to be mounted at one or more of the surfaces and/or windows of said automobile to ensure solar exposure for producing electrical power, said solar-energy grid adapted to provide a trickle charge to said at least one battery, and

- 15 a programmable controller module, said controller module adapted to monitor the voltage level of said at least one battery, the passenger-compartment ambient temperature, and the operating status of said automobile,

wherein said programmable controller module is further adapted to start said air-conditioning system and set the power mode for said air-conditioning system.

- 20 35. The system of claim 33, wherein said non-reactive filler material is selected from the group consisting of Silicon Nitride, Silicon Carbide, Titanium Diboride, Aluminum Oxide, and Mullite.

- 25 36. The system of claim 34, wherein said power mode set by said programmable controller module is selected from the group consisting of powered by an automobile's engine electrical system, powered by said independent DC electrical system using said battery, and recharging mode of said battery from said solar-energy grid.

- 30 37. The system of claim 34, wherein said programmable controller module comprises a computer-readable medium, said computer-readable medium containing programmed instructions that cause said independent DC electrical system to energize said one or more passenger-compartment forced-air circulation devices and activate said air-conditioning system at a pre-determined day and time, for a pre-determined interval, while said automobile engine is not running.

38. The system of claim 34, wherein said programmable controller module comprises a computer-readable medium, said computer-readable medium containing programmed instructions that cause the powering of said air-conditioning system to emanate from said independent DC electrical system instead of said automobile's engine electrical system when said automobile slows to a predetermined speed or less.

39. The system of claim 34, wherein said programmable controller module comprises a computer-readable medium, said computer-readable medium containing programmed instructions that cause the powering of said air-conditioning system to emanate from said independent DC electrical system instead of said automobile's engine electrical system when said automobile is at a standstill while said automobile engine is running and said automobile's transmission is in a park or neutral state.

40. The system of claim 34, wherein:

said programmable controller module is adapted for wireless communication in order to enable remote-control operations by a user; and

said air-conditioning system can be remotely started and stopped by a user using a remote keyless device.

41. The system of claim 34, wherein:

said programmable controller module is adapted for wireless communication in order to enable remote-control operations by a user; and

said air-conditioning system can be remotely started and stopped by a user using a mobile application on a wireless communications device.

42. A method of making an air-conditioning system for an automobile, comprising the steps of:

providing a thermal-electric cooler (TEC) module, having one or more Peltier junctions;

providing a thermal-energy-storage (TES) unit comprised of at least one low-pressure container containing a non-reactive filler material,

wherein the non-reactive filler material is adapted to absorb heat and melt above a predetermined threshold, and conversely is adapted to release stored heat and freeze at a predetermined threshold; and

providing one or more forced-air-circulation devices for circulating ambient air between the passenger compartment of an automobile, and said TEC module and TES unit.

43. The method of claim 42, further comprising the step of providing an independent DC electrical system, independent of said automobile's engine electrical system, said independent DC electrical system comprised of:

at least one battery for providing power to said air-conditioning system when said automobile engine is shutdown,

a solar-energy grid, said solar-energy grid adapted to be mounted at one or more of the surfaces and/or windows of said automobile to ensure solar exposure for producing electrical power, said solar-energy grid adapted to provide a trickle charge to said at least one battery, and

a programmable controller module, said controller module adapted to monitor the voltage level of said at least one battery, the passenger-compartment ambient temperature, and the operating status of said automobile,

wherein said programmable controller module is further adapted to start said air-conditioning system and set the power mode for said air-conditioning system.

44. The method of claim 42, wherein said non-reactive filler material is selected from the group consisting of Silicon Nitride, Silicon Carbide, Titanium Diboride, Aluminum Oxide, and Mullite.

45. The method of claim 43, wherein said power mode set by said programmable controller module is selected from the group consisting of powered by an automobile's engine electrical system, powered by said independent DC electrical system using said battery, and recharging mode of said battery from said solar-energy grid.

46. The method of claim 43, wherein said programmable controller module comprises a computer-readable medium, said computer-readable medium containing programmed instructions that cause said independent DC electrical system to energize said one or more passenger-compartment forced-air circulation devices and activate said air-conditioning system at a pre-determined day and time, for a pre-determined interval, while said automobile engine is not running.

47. The method of claim 43, wherein said programmable controller module comprises a computer-readable medium, said computer-readable medium containing programmed instructions that cause the powering of said air-conditioning system to emanate from said independent DC electrical system instead of said automobile's engine electrical system when said automobile slows to a predetermined speed or less.

48. The method of claim 43, wherein said programmable controller module comprises a computer-readable medium, said computer-readable medium containing programmed instructions that cause the powering of said air-conditioning system to emanate from said independent DC electrical system instead of said automobile's engine electrical system when said automobile is at a standstill while said automobile engine is running and said automobile's transmission is in a park or neutral state.

49. The method of claim 43, wherein:

said programmable controller module is adapted for wireless communication in order to enable remote-control operations by a user; and

said air-conditioning system can be remotely started and stopped by a user using a remote keyless device.

50. The method of claim 43, wherein:

said programmable controller module is adapted for wireless communication in order to enable remote-control operations by a user; and

said air-conditioning system can be remotely started and stopped by a user using a mobile application on a wireless communications device.

51. A method of using an air-conditioning system for an automobile according to claim 40, said method comprising the step of:

using a remote keyless device, remotely causing said automobile's air-conditioning system to start.

52. A method of using an air-conditioning system for an automobile according to claim 40, said method comprising the step of:

using a remote keyless device, remotely causing said automobile's air-conditioning system to stop.

53. A method of using an air-conditioning system for an automobile according to claim 41, said method comprising the step of:

using a mobile application on a wireless communications device, remotely causing said automobile's air-conditioning system to start.

54. A method of using an air-conditioning system for an automobile according to claim 41, said method comprising the step of:

using a mobile application on a wireless communications device, remotely causing said automobile's air-conditioning system to stop.

55. An air-conditioning system for an automobile, said automobile having an engine, said air-conditioning system comprising:

5 a refrigerant compressor,

said refrigerant compressor having a first housing end bell,

said refrigerant compressor having a second housing end bell,

said refrigerant compressor having an inlet and an outlet for transporting refrigerant, and

10 said refrigerant compressor having a central drive shaft that when turned with rotational force causes said compressor to compress refrigerant gasses contained therein;

a first compressor-driving pulley adapted to facilitate the rotational driving of said compressor via the use of a pulley belt driven by said automobile engine;

15 a first electric clutch assembly adapted to facilitate the selective coupling of said first pulley with said central drive shaft, when said electric clutch assembly is energized;

a second compressor-driving pulley directly coupled to said central drive shaft to facilitate the rotational driving of said compressor via a pulley belt driven by a power source that does not rely on the running of said automobile engine;

20 an electrical motor adapted to be able to drive said refrigerant compressor via a pulley system,

wherein said electrical motor is adapted to be powered from an independent DC power source that does not depend on the running of the engine of said automobile,

25 wherein the shaft of said electrical motor is adapted to drive a third pulley mounted at one end of the housing of said electrical motor, said third pulley coupled to said second compressor-driving pulley via a pulley belt, and

wherein said electrical motor is adapted to have a second electric clutch assembly to allow the selective coupling of said electrical motor's shaft and said third

30 pulley, depending on whether said electric clutch assembly is energized;

an evaporator for transferring heat from the passenger compartment air of said

automobile to said refrigerant circulated within said evaporator;

a condenser for transferring heat from refrigerant to the outside atmosphere;

at least one electric heat-sink fan for circulating outside air around said condenser;

a thermal-electric cooler (TEC) module, having one or more Peltier junctions;

- 5 a thermal-energy-storage (TES) unit comprised of at least one low-pressure container containing a non-reactive filler material,

wherein the non-reactive filler material is adapted to absorb heat and melt above a predetermined threshold, and conversely is adapted to release stored heat and freeze at a predetermined threshold;

- 10 one or more forced-air-circulation devices for circulating ambient air between the passenger compartment of an automobile and said evaporator, TEC module, and TES unit; and

an independent DC electrical system, independent of said automobile's engine electrical system, comprised of:

- 15 at least one battery for providing power to said air-conditioning system when said automobile engine is shutdown,

a solar-energy grid, said solar-energy grid adapted to be mounted at one or more surfaces and/or windows of said automobile to ensure solar exposure for producing electrical power, said solar-energy grid adapted to provide a trickle

- 20 charge to said at least one battery, and

a programmable controller module, said controller module adapted to monitor the voltage level of said at least one battery, the passenger-compartment ambient temperature, and the operating status of said automobile,

- 25 wherein said programmable controller module is further adapted to start said air-conditioning system and set the power mode for said air-conditioning system,

wherein said programmable controller module is further adapted to select the operating mode of said air-conditioning system, and

- 30 wherein said programmable controller module is adapted to prevent the simultaneous engagement of said first and second electric clutches.

56. The system of claim 55, wherein said non-reactive filler material is selected from the

group consisting of Silicon Nitride, Silicon Carbide, Titanium Diboride, Aluminum Oxide, and Mullite.

57. The system of claim 55, wherein said programmable controller module can select an air-conditioning system operating mode is selected from the group consisting of compressor-based, TEC-based, and OFF.

58. The system of claim 55, wherein:

said first compressor-driving pulley is adapted to receive a pulley belt of a type selected from the group consisting of serpentine, V-belt, V-link, and flat; and

said second compressor-driving pulley is adapted to receive a pulley belt of a type selected from the group consisting of serpentine, V-belt, V-link, and flat.

59. The system of claim 55, wherein:

said first and second compressor-driving pulleys are mounted on the same end of said central drive shaft;

said electric clutch assembly is equipped with an outer hub at which said first compressor-driving pulley is adapted to be selectively coupled to said central drive shaft;

said second compressor-driving pulley is directly coupled to said central drive shaft via the neck of said outer hub, onto which is installed an additional roller bearing.

60. The system of claim 55, wherein:

said first and second compressor-driving pulleys are mounted on opposite ends of said central drive shaft with respect to each other;

said central drive shaft is modified to extend beyond each compressor housing end bell in order to support one of said first and second pulleys at each end of said compressor;

each of said first and second housing end bells are substantially structurally identical, each having a bearing adapted to support said central drive shaft and each having packing seals for inhibiting the leakage of either lubricants or refrigerant;

at one end of said compressor, said electric clutch assembly is equipped with an outer hub at which said first compressor-driving pulley is adapted to be selectively coupled to said central drive shaft; and

at the other end of said compressor, said second compressor-driving pulley is directly

coupled to said compressor's drive shaft via the neck of respective housing end bell,
onto which is installed an additional roller bearing.

61. The system of claim 55, wherein said power mode set by said programmable controller module is selected from the group consisting of powered by said engine, powered by
5 said independent DC electrical system using said battery, and recharging mode of said battery from said solar-energy grid.
62. The system of claim 55, wherein said programmable controller module comprises a computer-readable medium, said computer-readable medium containing programmed instructions that cause said independent DC electrical system to energize said second
10 electric clutch, said electrical motor, said one or more forced-air-circulation devices, and said at least one heat-sink fan to energize and activate said air-conditioning system at a pre-determined day and time, for a pre-determined interval, while said automobile engine is not running.
63. The system of claim 55, wherein said programmable controller module comprises a
15 computer-readable medium, said computer-readable medium containing programmed instructions that cause the powering of said air-conditioning system to emanate from said independent DC electrical system while disengaging said first electric clutch when said automobile slows to a predetermined speed or less.
64. The system of claim 55, wherein said programmable controller module comprises a
20 computer-readable medium, said computer-readable medium containing programmed instructions that cause the powering of said air-conditioning system to emanate from said independent DC electrical system instead of said automobile's engine electrical system when said automobile slows to a predetermined speed or less.
65. The system of claim 55, wherein said programmable controller module comprises a
25 computer-readable medium, said computer-readable medium containing programmed instructions that cause the powering of said air-conditioning system to emanate from said independent DC electrical system while disengaging said first electric clutch when said automobile is at a standstill while said automobile engine is running and said automobile's transmission is in a park or neutral state.
66. The system of claim 55, wherein said programmable controller module comprises a
30 computer-readable medium, said computer-readable medium containing programmed instructions that cause the powering of said air-conditioning system to emanate from

said independent DC electrical system instead of said automobile's engine electrical system when said automobile is at a standstill while said automobile engine is running and said automobile's transmission is in a park or neutral state.

67. The system of claim 55, wherein said programmable controller module comprises a computer-readable medium, said computer-readable medium containing programmed instructions that can cause the operating mode of said air-conditioning system to switch between a compressor-based air-conditioning mode and a TEC-based air-conditioning mode.

68. The system of claim 55, wherein said programmable controller module comprises a computer-readable medium, said computer-readable medium containing programmed instructions that can prevents the air-conditioning system to simultaneously operate in a compressor-based air-conditioning mode and a TEC-based air-conditioning mode.

69. The system of claim 55, wherein:

said programmable controller module is adapted for wireless communication in order to enable remote-control operations by a user; and

said air-conditioning system can be remotely started and stopped by a user using a remote keyless device.

70. The system of claim 55, wherein:

said programmable controller module is adapted for wireless communication in order to enable remote-control operations by a user; and

said air-conditioning system can be remotely started and stopped by a user using a mobile application on a wireless communications device.

71. A method of making an air-conditioning system for an automobile, said automobile having an engine, said air-conditioning system comprising the steps of:

providing a refrigerant compressor,

said refrigerant compressor having a first housing end bell,

said refrigerant compressor having a second housing end bell,

said refrigerant compressor having an inlet and an outlet for transporting refrigerant, and

said refrigerant compressor having a central drive shaft that when turned with

rotational force causes said compressor to compress refrigerant gasses contained therein;

providing a first compressor-driving pulley adapted to facilitate the rotational driving of said compressor via the use of a pulley belt driven by said automobile engine;

5 providing a first electric clutch assembly adapted to facilitate the selective coupling of said first pulley with said central drive shaft, when said electric clutch assembly is energized;

providing a second compressor-driving pulley directly coupled to said central drive shaft to facilitate the rotational driving of said compressor via a pulley belt driven by a power source that does not rely on the running of said automobile engine;

10 providing an electrical motor adapted to be able to drive said refrigerant compressor via a pulley system,

wherein said electrical motor is adapted to be powered from an independent DC power source that does not depend on the running of the engine of said automobile,

15 wherein the shaft of said electrical motor is adapted to drive a third pulley mounted at one end of the housing of said electrical motor, said third pulley coupled to said second compressor-driving pulley via a pulley belt, and

wherein said electrical motor is adapted to have a second electric clutch assembly to allow the selective coupling of said electrical motor's shaft and said third pulley, depending on whether said electric clutch assembly is energized;

20 providing an evaporator for transferring heat from the passenger compartment air of said automobile to said refrigerant circulated within said evaporator;

providing a condenser for transferring heat from refrigerant to the outside atmosphere;

25 providing at least one electric heat-sink fan for circulating outside air around said condenser;

providing a thermal-electric cooler (TEC) module, having one or more Peltier junctions;

providing a thermal-energy-storage (TES) unit comprised of at least one low-pressure container containing a non-reactive filler material,

30 wherein the non-reactive filler material is adapted to absorb heat and melt above a predetermined threshold, and conversely is adapted to release stored heat and

freeze at a predetermined threshold;

providing one or more forced-air-circulation devices for circulating ambient air between the passenger compartment of an automobile and said evaporator, TEC module, and TES unit; and

- 5 providing an independent DC electrical system, independent of said automobile's engine electrical system, comprised of:

at least one battery for providing power to said air-conditioning system when said automobile engine is shutdown,

- 10 a solar-energy grid, said solar-energy grid adapted to be mounted at one or more surfaces and/or windows of said automobile to ensure solar exposure for producing electrical power, said solar-energy grid adapted to provide a trickle charge to said at least one battery, and

- 15 a programmable controller module, said controller module adapted to monitor the voltage level of said at least one battery, the passenger-compartment ambient temperature, and the operating status of said automobile,

wherein said programmable controller module is further adapted to start said air-conditioning system and set the power mode for said air-conditioning system,

- 20 wherein said programmable controller module is further adapted to select the operating mode of said air-conditioning system, and

wherein said programmable controller module is adapted to prevent the simultaneous engagement of said first and second electric clutches.

- 25 72. The method of claim 71, wherein said non-reactive filler material is selected from the group consisting of Silicon Nitride, Silicon Carbide, Titanium Diboride, Aluminum Oxide, and Mullite.

73. The method of claim 71, wherein said programmable controller module can select an air-conditioning system operating mode is selected from the group consisting of compressor-based, TEC-based, and OFF.

74. The method of claim 71, wherein:

- 30 said first compressor-driving pulley is adapted to receive a pulley belt of a type selected from the group consisting of serpentine, V-belt, V-link, and flat; and

said second compressor-driving pulley is adapted to receive a pulley belt of a type selected from the group consisting of serpentine, V-belt, V-link, and flat.

75. The method of claim 71, wherein:

said first and second compressor-driving pulleys are mounted on the same end of said central drive shaft;

said electric clutch assembly is equipped with an outer hub at which said first compressor-driving pulley is adapted to be selectively coupled to said central drive shaft;

said second compressor-driving pulley is directly coupled to said central drive shaft via the neck of said outer hub, onto which is installed an additional roller bearing.

76. The method of claim 71, wherein:

said first and second compressor-driving pulleys are mounted on opposite ends of said central drive shaft with respect to each other;

said central drive shaft is modified to extend beyond each compressor housing end bell in order to support one of said first and second pulleys at each end of said compressor;

each of said first and second housing end bells are substantially structurally identical, each having a bearing adapted to support said central drive shaft and each having packing seals for inhibiting the leakage of either lubricants or refrigerant;

at one end of said compressor, said electric clutch assembly is equipped with an outer hub at which said first compressor-driving pulley is adapted to be selectively coupled to said central drive shaft; and

at the other end of said compressor, said second compressor-driving pulley is directly coupled to said compressor's drive shaft via the neck of respective housing end bell, onto which is installed an additional roller bearing.

77. The method of claim 71, wherein said power mode set by said programmable controller module is selected from the group consisting of powered by said engine, powered by said independent DC electrical system using said battery, and recharging mode of said battery from said solar-energy grid.

78. The method of claim 71, wherein said programmable controller module comprises a computer-readable medium, said computer-readable medium containing programmed instructions that cause said independent DC electrical system to energize said second

electric clutch, said electrical motor, said one or more forced-air-circulation devices, and said at least one heat-sink fan to energize and activate said air-conditioning system at a pre-determined day and time, for a pre-determined interval, while said automobile engine is not running.

- 5 79. The method of claim 71, wherein said programmable controller module comprises a computer-readable medium, said computer-readable medium containing programmed instructions that cause the powering of said air-conditioning system to emanate from said independent DC electrical system while disengaging said first electric clutch when said automobile slows to a predetermined speed or less.
- 10 80. The method of claim 71, wherein said programmable controller module comprises a computer-readable medium, said computer-readable medium containing programmed instructions that cause the powering of said air-conditioning system to emanate from said independent DC electrical system instead of said automobile's engine electrical system when said automobile slows to a predetermined speed or less.
- 15 81. The method of claim 71, wherein said programmable controller module comprises a computer-readable medium, said computer-readable medium containing programmed instructions that cause the powering of said air-conditioning system to emanate from said independent DC electrical system while disengaging said first electric clutch when said automobile is at a standstill while said automobile engine is running and said
20 automobile's transmission is in a park or neutral state.
82. The method of claim 71, wherein said programmable controller module comprises a computer-readable medium, said computer-readable medium containing programmed instructions that cause the powering of said air-conditioning system to emanate from said independent DC electrical system instead of said automobile's engine electrical
25 system when said automobile is at a standstill while said automobile engine is running and said automobile's transmission is in a park or neutral state.
83. The method of claim 71, wherein said programmable controller module comprises a computer-readable medium, said computer-readable medium containing programmed instructions that can cause the operating mode of said air-conditioning system to switch
30 between a compressor-based air-conditioning mode and a TEC-based air-conditioning mode.
84. The method of claim 71, wherein said programmable controller module comprises a

computer-readable medium, said computer-readable medium containing programmed instructions that can prevents the air-conditioning system to simultaneously operate in a compressor-based air-conditioning mode and a TEC-based air-conditioning mode.

85. The method of claim 71, wherein:

5 said programmable controller module is adapted for wireless communication in order to enable remote-control operations by a user; and
 said air-conditioning system can be remotely started and stopped by a user using a remote keyless device.

86. The method of claim 71, wherein:

10 said programmable controller module is adapted for wireless communication in order to enable remote-control operations by a user; and
 said air-conditioning system can be remotely started and stopped by a user using a mobile application on a wireless communications device.

87. A method of using an air-conditioning system for an automobile according to claim 69,
15 said method comprising the step of:

 using a remote keyless device, remotely causing said automobile's air-conditioning system to start.

88. A method of using an air-conditioning system for an automobile according to claim 69,
 said method comprising the step of:

20 using a remote keyless device, remotely causing said automobile's air-conditioning system to stop.

89. A method of using an air-conditioning system for an automobile according to claim 70,
 said method comprising the step of:

25 using a mobile application on a wireless communications device, remotely causing said automobile's air-conditioning system to start.

90. A method of using an air-conditioning system for an automobile according to claim 70,
 said method comprising the step of:

 using a mobile application on a wireless communications device, remotely causing said automobile's air-conditioning system to stop.

91. A method of using an air-conditioning system for an automobile according to claim 67, said method comprising the step of:

using a remote keyless device, remotely causing said automobile's air-conditioning system to start,

5 wherein the compressor-based subsystem of the air-conditioning system initially starts, as run via said DC motor powered from said independent DC electrical system, and runs until a predetermined passenger-compartment temperature is reached, and

10 wherein after said predetermined temperature is reached, said compressor-based subsystem is disengaged and de-energized, and said TEC-based subsystem is energized to maintain said passenger-compartment temperature within a predetermined range.

92. A method of using an air-conditioning system for an automobile according to claim 67, said method comprising the step of:

15 using a mobile application on a wireless communications device, remotely causing said automobile's air-conditioning system to start,

20 wherein the compressor-based subsystem of the air-conditioning system initially starts, as run via said DC motor powered from said independent DC electrical system, and runs until a predetermined passenger-compartment temperature is reached, and

 wherein after said predetermined temperature is reached, said compressor-based subsystem is disengaged and de-energized, and said TEC-based subsystem is energized to maintain said passenger-compartment temperature within a predetermined range.

25

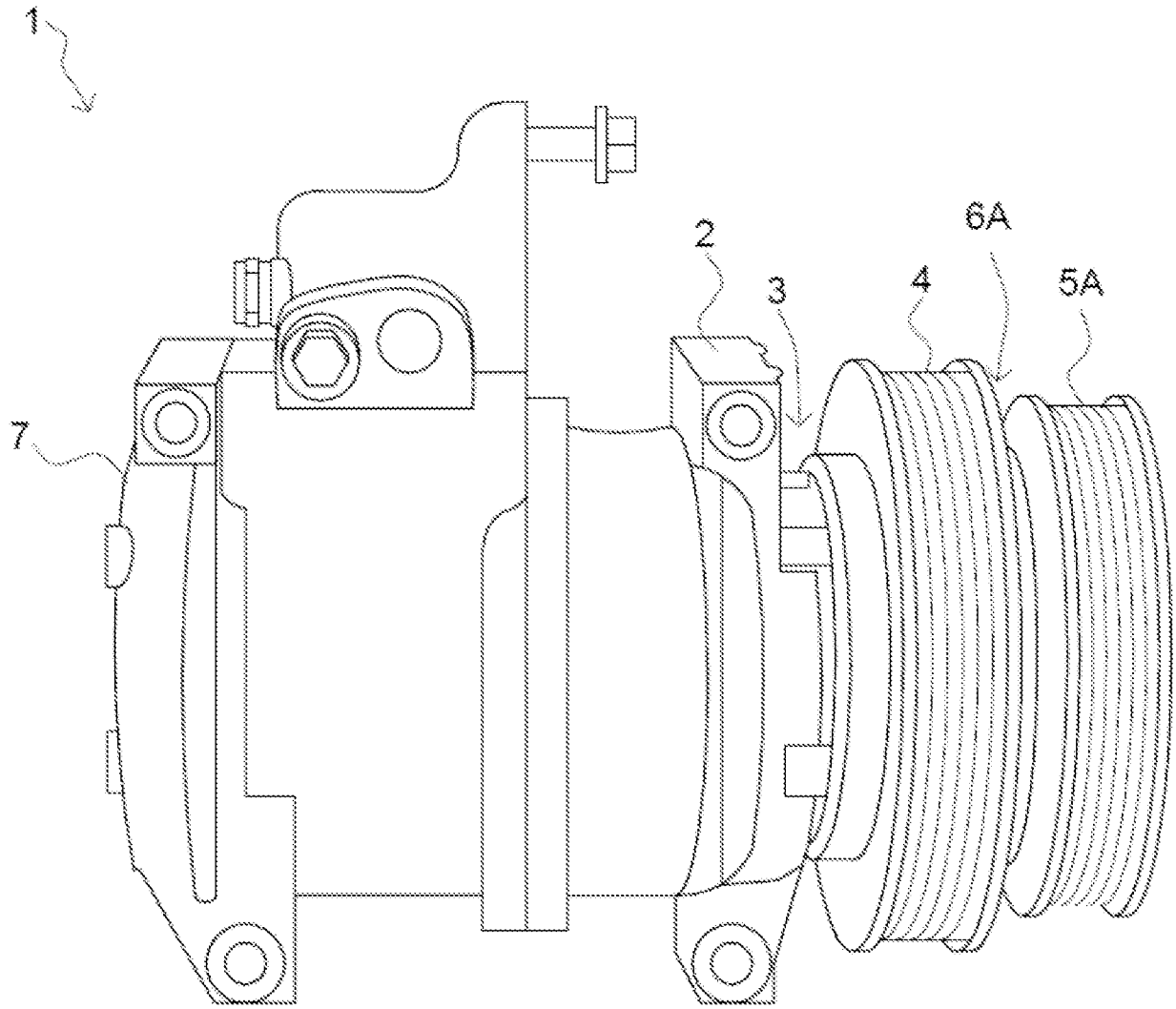


FIG. 1A

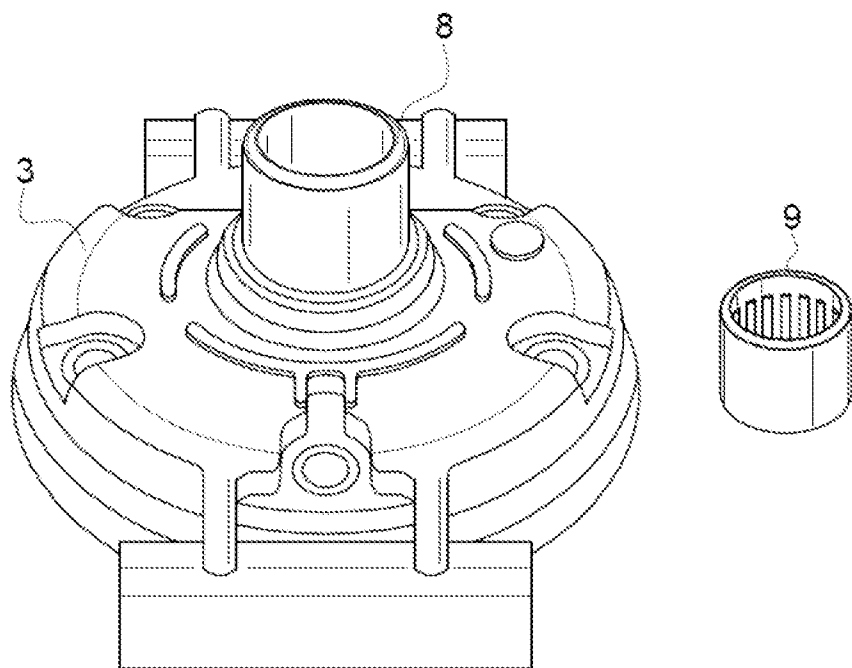


FIG. 1B

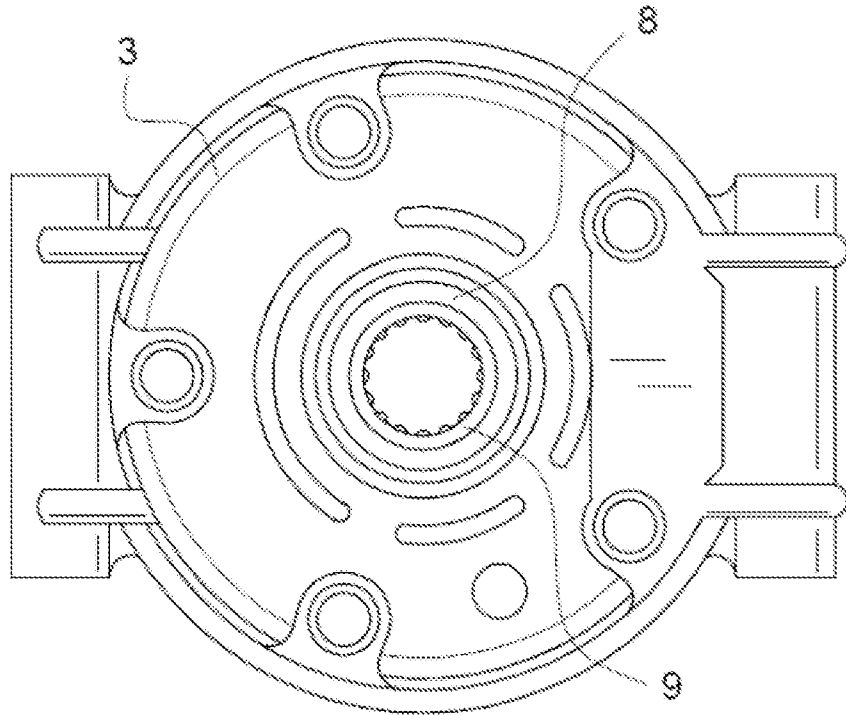


FIG. 1C

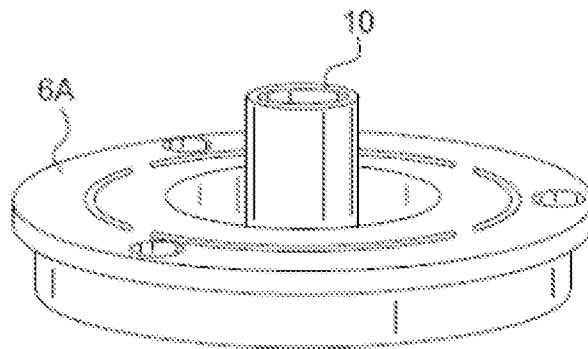


FIG. 1D

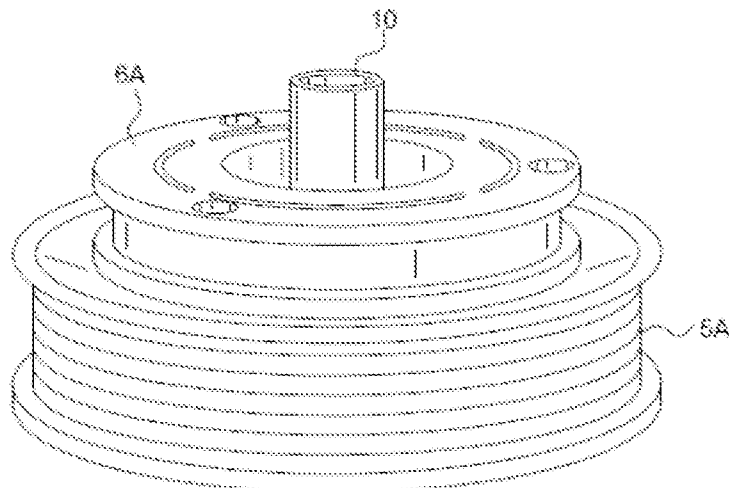


FIG. 1E

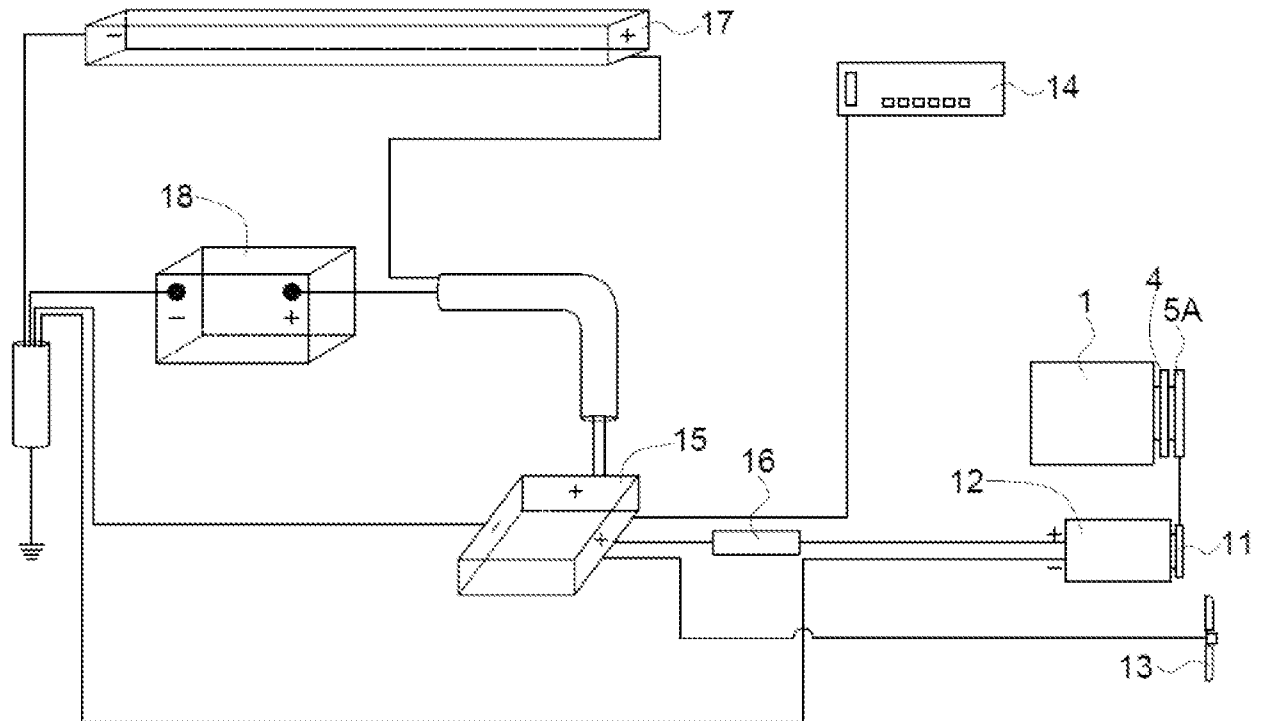


FIG. 2

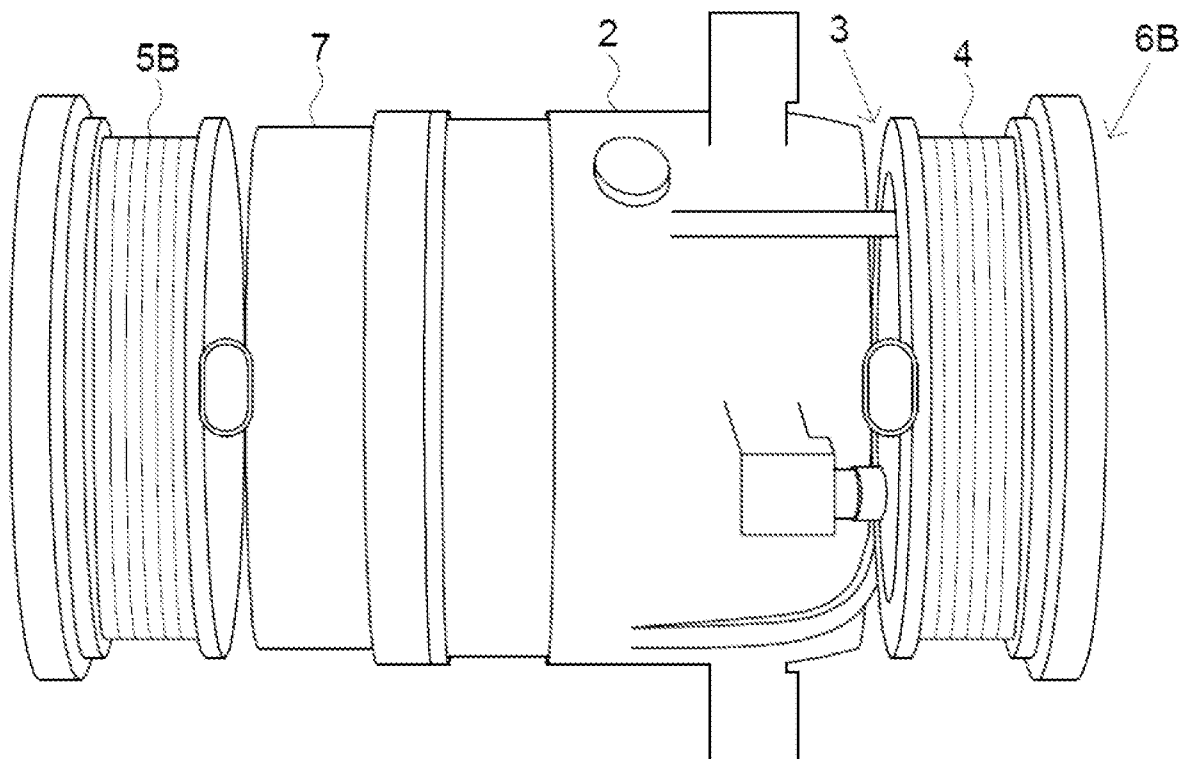


FIG. 3

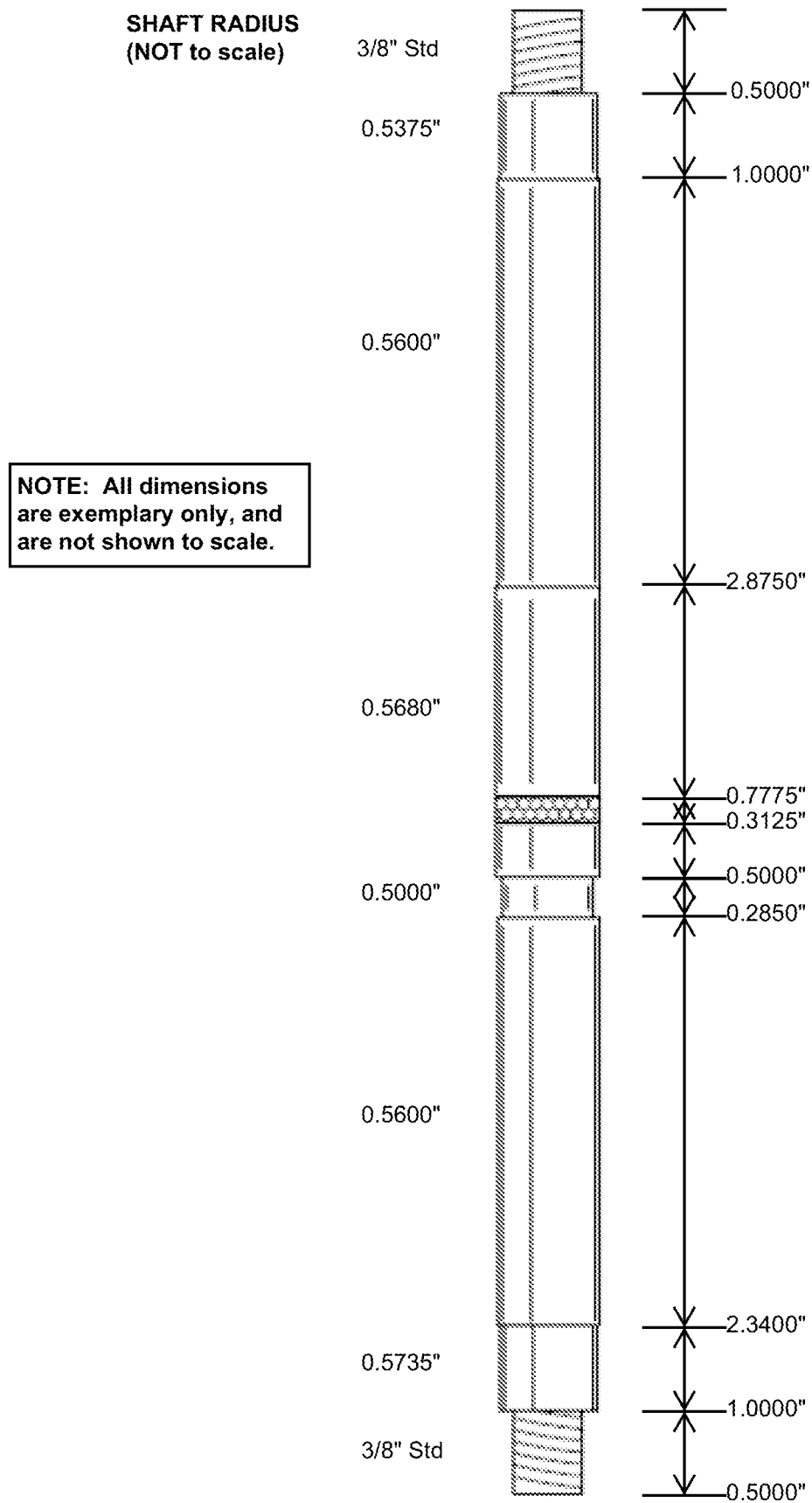


FIG. 4

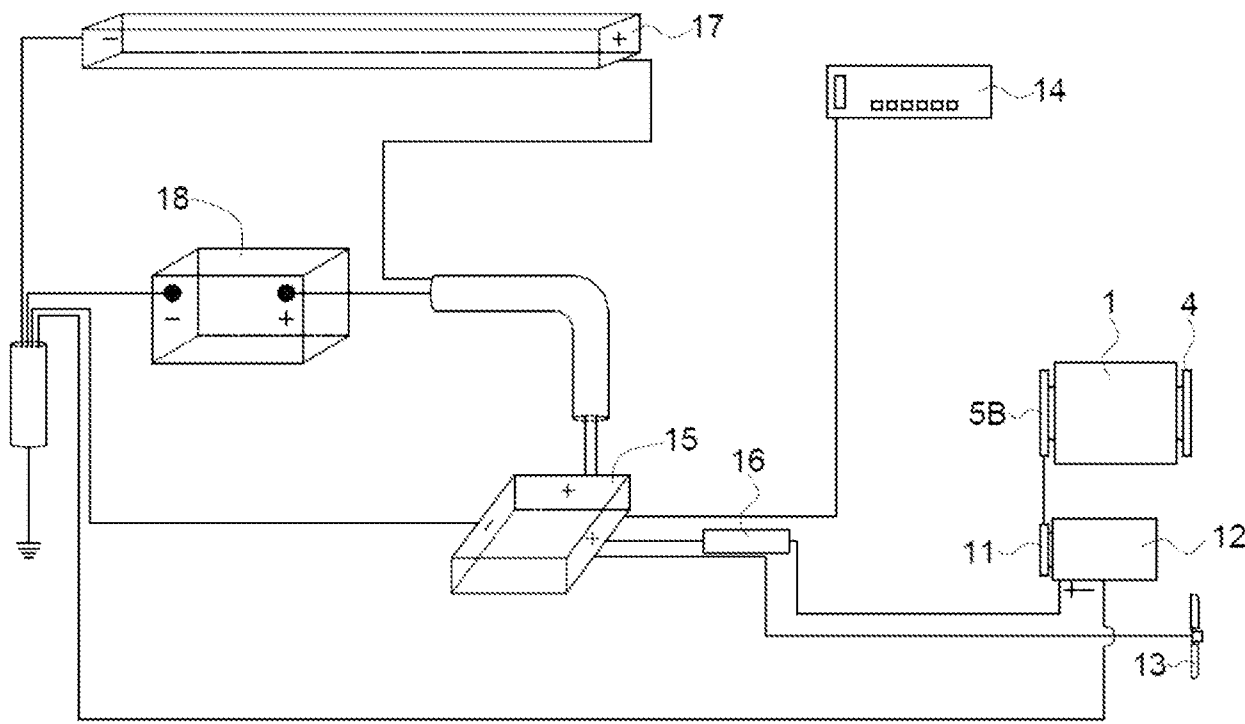


FIG. 5

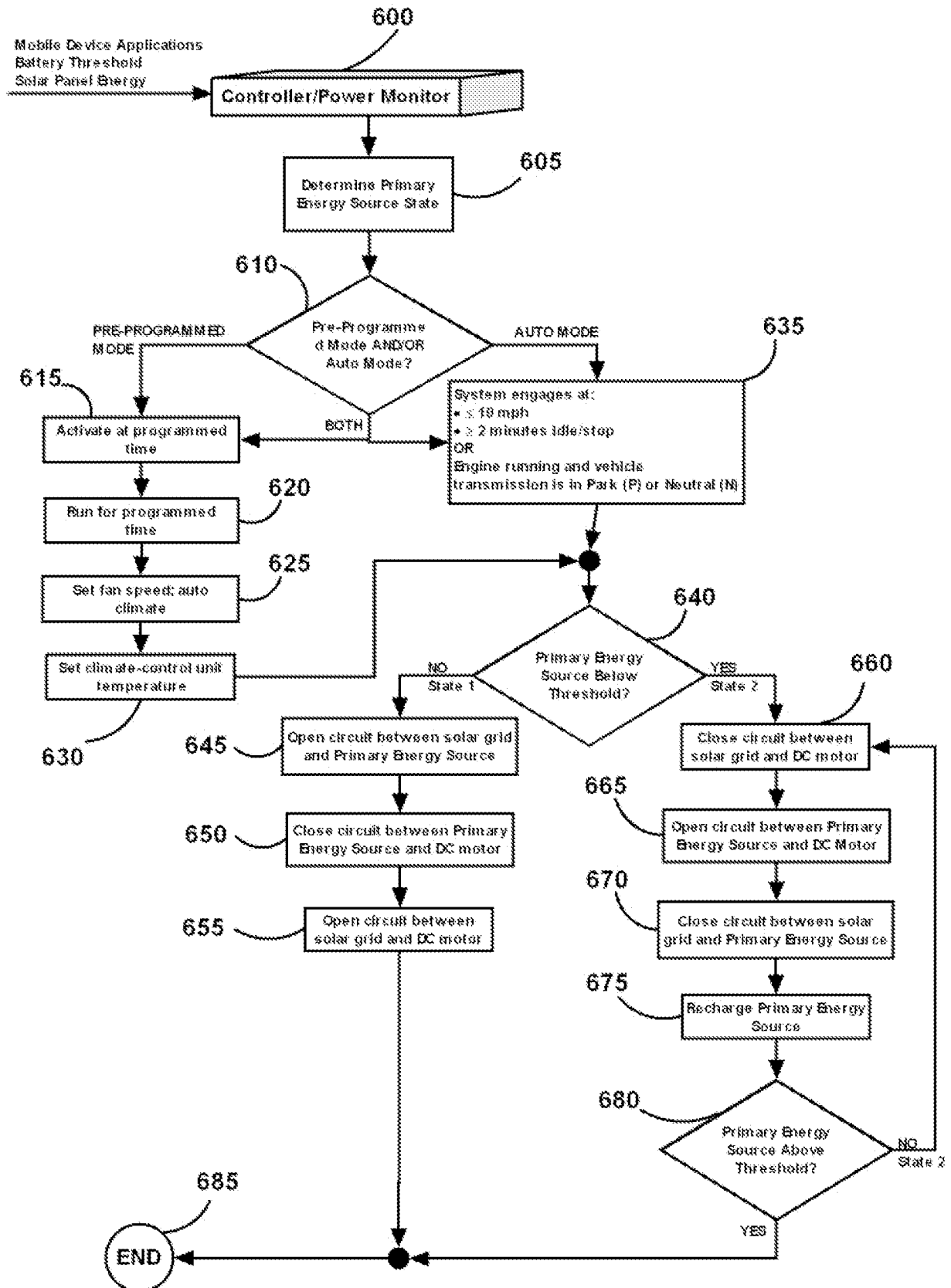


FIG. 6

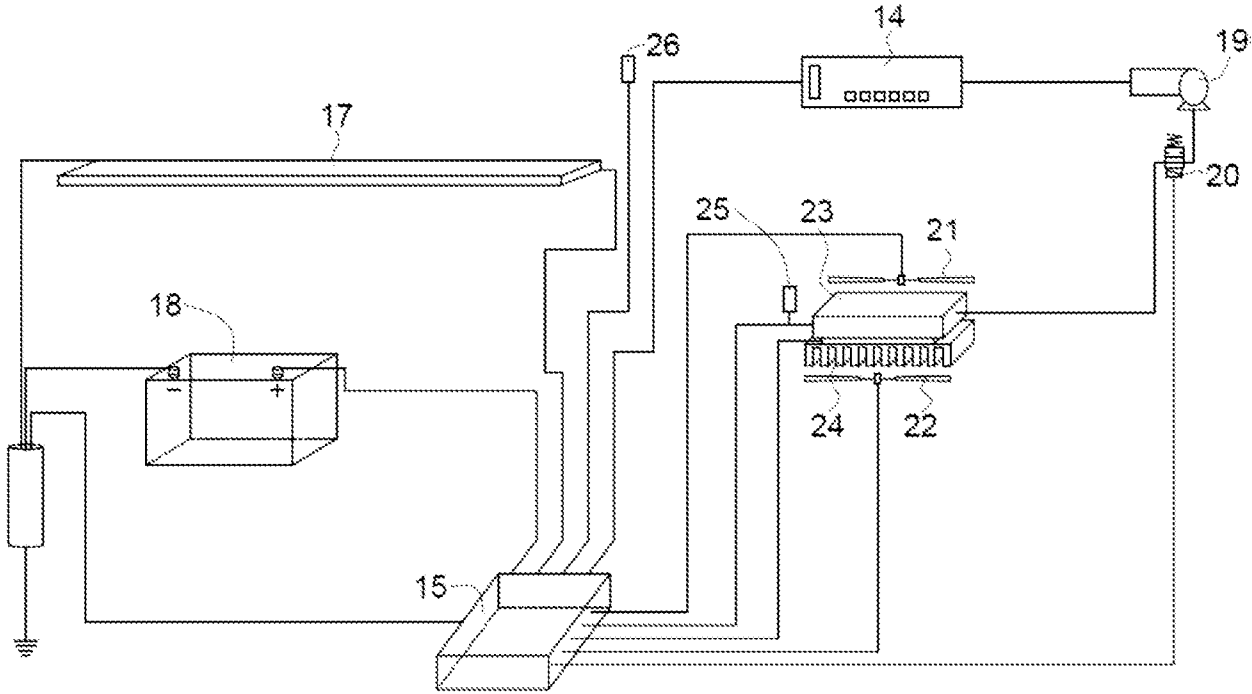


FIG. 7

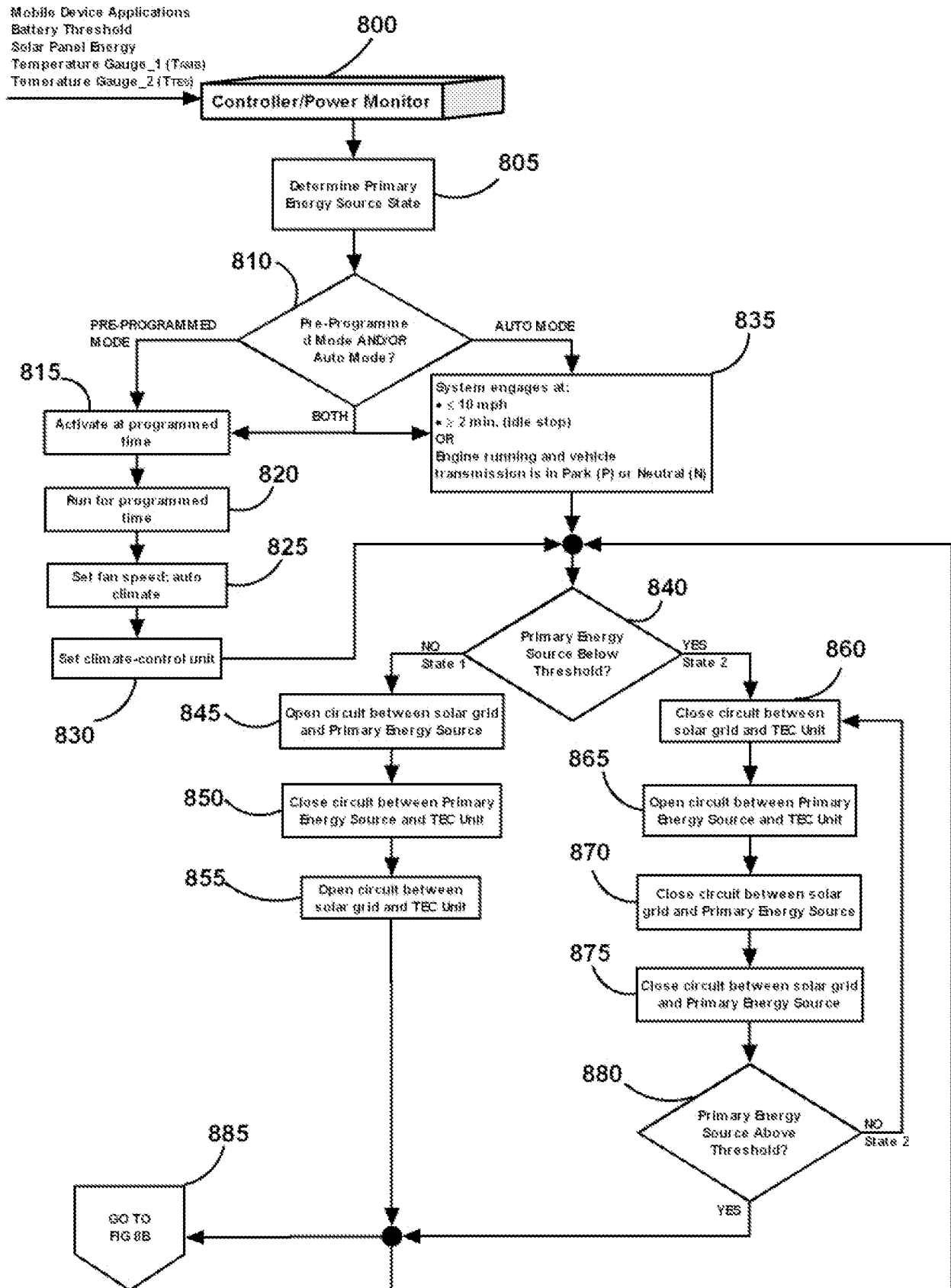


FIG. 8A

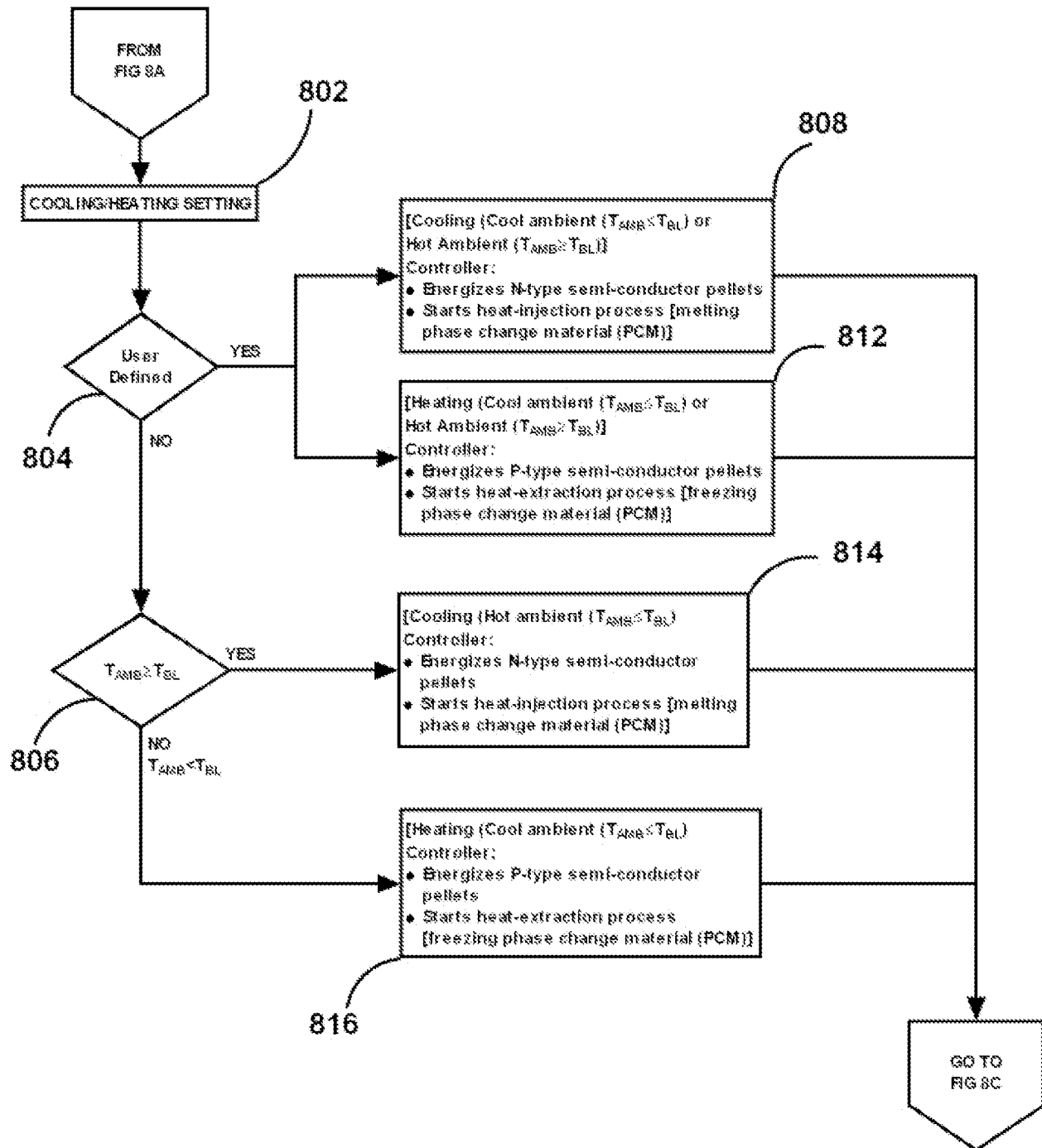


FIG. 8B

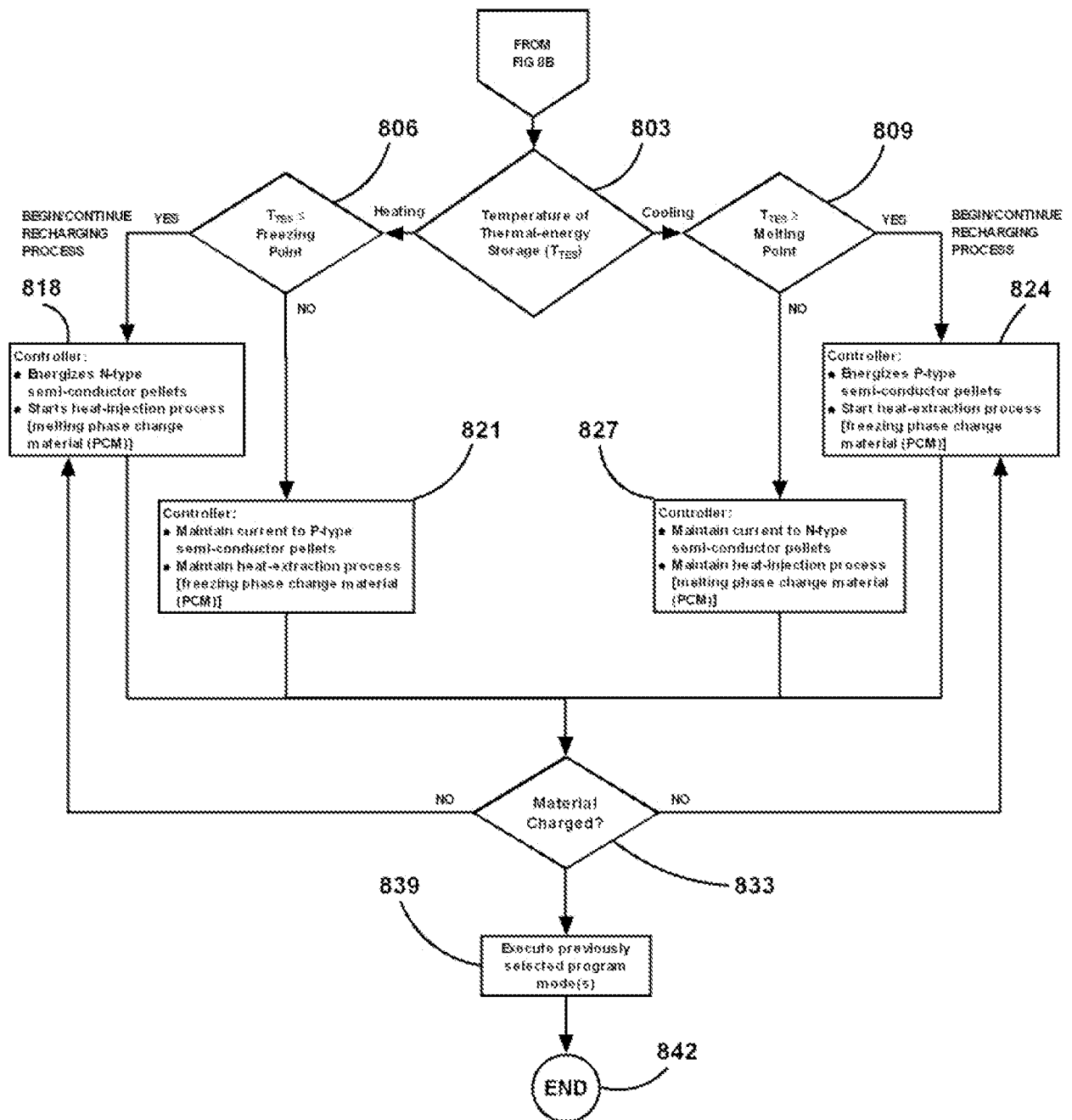


FIG. 8C

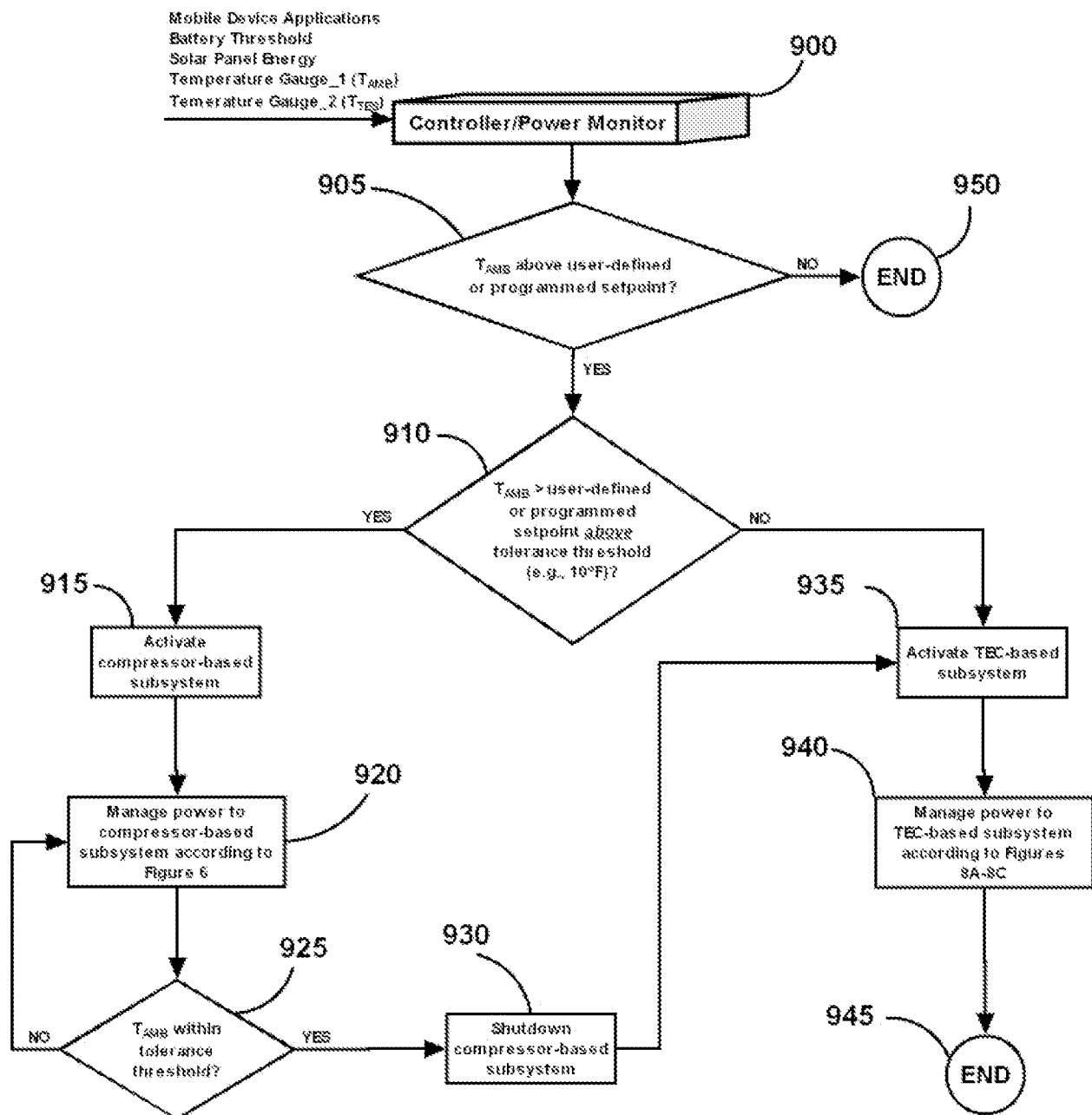


FIG. 9