Title: VEHICLE SURFACE CLEANING AND DE-ICING

Abstract: Apparatus for supplying heated liquid for use in cleaning a vehicle surface including a liquid container having an inlet through which a liquid is received from a reservoir and an outlet through which the liquid is discharged for cleaning the vehicle surface, the liquid container including a first heating chamber a second heating chamber and a heat transfer element in direct thermal contact with the first heating chamber and the second heating chamber and defining at least a portion of an external wall of the liquid container and a heating element adjacent the heat transfer element operative to heat the heat transfer element and thereby heat the liquid in the first heating chamber and the second heating chamber.

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VEHICLE SURFACE CLEANING AND DE-ICING

REFERENCE TO RELATED APPLICATIONS

Reference is made to U.S. Provisional Patent Application Serial No. 60/728,651, filed October 19, 2005 and entitled "RF Interface for Heated Windshield Washing System," U.S. Provisional Patent Application Serial No. 60/741,211, filed November 30, 2005 and entitled "Vehicle Heated Liquid Washing System" and U.S. Provisional Patent Application Serial No. 60/843,782, filed September 11, 2006 and entitled "Vehicle Surface Cleaning & De-Icing" the disclosures of which are hereby incorporated by reference and priority of which are hereby claimed pursuant to 37 CFR 1.78(a) (4) and (5)(i).

Reference is made to applicant's copending PCT Application Serial No. PCT/IL2005/00179 filed February 11, 2005, the disclosure of which is hereby incorporated by reference.

Reference is made to applicant's copending U.S. Patent Application Serial No. 10/700,141 filed November 3, 2003, the disclosure of which is hereby incorporated by reference. Reference is made to applicant's copending U.S. Patent Application Serial No. 11/203,779 filed August 15, 2005, the disclosure of which is hereby incorporated by reference.

Reference is made to applicant's copending U.S. Patent Application Serial No. 10/477,486 filed June 21, 2004, the disclosure of which is hereby incorporated by reference. Reference is made to applicant's copending U.S. Patent Application Serial No. 11/531,979 filed April 20, 2005, the disclosure of which is hereby incorporated by reference.

FIELD OF THE INVENTION

The present invention relates generally to apparatus and methods for cleaning or de-icing vehicle elements.
BACKGROUND OF THE INVENTION

The following publications are believed to represent the current state of the art:

U.S. Patents: 653,629; 1,636,190; 2,607,944; 3,202,447; 3,203,447;
3,319,891; 3,332,045; 3,446,942; 3,427,675; 3,475,588; 3,632,042; 3,524,044;
3,537,900; 3,643,193; 3,711,679; 3,716,886; 3,747,500; 3,888,412; 3,977,436;
3,979,068; 4,090,668; 4,088,269; 4,106,508; 4,159,026; 4,212,425; 4,253,493;
4,295,111; 4,306,589; 4,403,765; 4,489,863; 4,508,957; 4,524,797; 4,534,539;
4,561,632; 4,574,841; 4,616,780; 4,638,525; 4,690,371; 4,815,662; 4,834,289;
4,877,186; 4,832,262; 4,922,570; 4,946,009; 5,012,977; 5,034,714; 5,118,040;
5,134,266; 5,141,157; 5,141,160; 5,173,586; 5,203,049; 5,254,083; 5,271,120;
5,318,071; 5,345,968; 5,351,934; 5,354,965; 5,383,247; 5,423,486; 5,467,522;
5,509,606; 5,561,882; 5,636,407; 5,650,080; 5,673,360; 5,711,487;
5,727,769; 5,762,278; 5,784,751; 5,823,439; 5,881,428; 5,903,953; 5,927,608;
5,944,910; 5,947,348; 5,957,384; 5,965,950; 5,979,796; 5,988,523; 5,988,529;
6,008,474; 6,024,803; 6,029,908; 6,032,324; 6,050,503; 6,082,632; 6,133,546;
6,164,564; 6,155,493; 6,199,587; 6,220,524; 6,223,951; 6,236,019; 6,330,497;
6,257,500; 6,281,649; 6,286,174; 6,615,438; 6,669,109; 6,892,417 and 7,108,754.

SUMMARY OF THE INVENTION

The present invention seeks to provide improved apparatus and methods for cleaning or de-icing vehicle elements.

There is thus provided in accordance with a preferred embodiment of the present invention apparatus for supplying heated liquid for use in cleaning a vehicle surface including a liquid container having an inlet through which a liquid is received from a reservoir and an outlet through which the liquid is discharged for cleaning the vehicle surface, the liquid container including a first heating chamber, a second heating chamber and a heat transfer element in direct thermal contact with the first heating chamber and the second heating chamber and defining at least a portion of an external wall of the liquid container and a heating element adjacent the heat transfer element operative to heat the heat transfer element and thereby heat the liquid in the first heating chamber and the second heating chamber.

Preferably, the liquid container also includes at least one enclosing element attached to the heat transfer element. Additionally, the heat transfer element defines a cover of the at least one enclosing element.

Preferably, the first heating chamber includes a rounded end portion.

Additionally or alternatively, the apparatus also includes at least one insulating cover assembly including a volume maintained under a vacuum.

Preferably, at least a portion of the at least one enclosing element is formed of rubber.

There is also provided in accordance with another preferred embodiment of the present invention a method for supplying heated liquid for use in cleaning a vehicle surface including providing a liquid container for heating a liquid, the liquid container including a first heating chamber, a second heating chamber and a heat transfer element in direct thermal contact with the first heating chamber and the second heating chamber and defining at least a portion of an external wall of the liquid container, receiving a liquid into the first heating chamber and the second heating chamber, heating the heat transfer element thereby heating the liquid in the first heating
chamber and the second heating chamber through the heat transfer element and discharging the liquid through an outlet onto the vehicle surface.

There is further provided in accordance with yet another preferred embodiment of the present invention apparatus for supplying heated liquid for use in cleaning a vehicle surface, including a vessel, having an inlet through which a liquid is received from a reservoir and an outlet through which the liquid is discharged for cleaning the vehicle surface, the vessel including a first heating chamber and a second heating chamber, a heat transfer cover, in direct thermal contact with the first heating chamber and the second heating chamber, operative to heat the liquid in the first heating chamber and the second heating chamber and a heating element adjacent the heat transfer cover operative to heat the heat transfer cover.

There is even further provided in accordance with still another preferred embodiment of the present invention a method for supplying heated liquid for use in cleaning a vehicle surface including providing a vessel for heating a liquid, the vessel including a first heating chamber and a second heating chamber, receiving a liquid into the vessel so that the liquid flows into the first heating chamber and the second heating chamber, heating a heat transfer cover in direct thermal contact with the first heating chamber and the second heating chamber, thereby heating the liquid in the first heating chamber and the second heating chamber through the heat transfer cover and discharging the liquid through an outlet onto the vehicle surface.

There is also provided in accordance with even still another preferred embodiment of the present invention a method for supplying heated liquid for use in cleaning a vehicle surface including receiving a liquid into a vessel, heating the liquid in the vessel and discharging the liquid through an outlet onto the vehicle surface, the heating the liquid including providing at least one heating element in thermal communication with the vessel and operating the at least one heating element in one of multiple operating modes including a heating element standby mode, the heating element standby mode including ascertaining a near-boiling temperature of the liquid, setting at least one pair of standby mode temperature thresholds, based at least partially on the near-boiling temperature, measuring a temperature of the liquid and controlling the at least one heating element based on the temperature and the temperature thresholds.
There is further provided in accordance with another preferred embodiment of the present invention apparatus for supplying heated liquid for use in cleaning a vehicle surface, including a vessel, having an inlet through which a liquid is received from a reservoir and an outlet through which the liquid is discharged for cleaning the vehicle surface, at least one heating element in thermal communication with the vessel, at least one temperature sensor operative to measure a temperature of the liquid in the vessel and a controller operative to operate the at least one heating element in one of multiple operating modes including a standby mode, the standby mode including ascertaining a near-boiling temperature of the liquid, setting at least one pair of standby mode temperature thresholds, based at least partially on the near-boiling temperature and controlling the at least one heating element based on the temperature and the temperature thresholds.

Preferably, the setting is based at least partially on input from at least one additional sensor. Additionally or alternatively, the controller is operative to select a primary temperature sensor including the at least one temperature sensor and the at least one pair of standby thresholds includes a pair of standby thresholds for each sensor of the at least one temperature sensor.

In accordance with another preferred embodiment of the present invention the apparatus also includes a circulation pump and the setting is based at least partially on an operating mode of the circulation pump. Additionally or alternatively, the apparatus also includes an RF actuator in communication with the controller, the controller being operative, upon receipt of a standby mode actuation from the RF actuator, to operate the at least one heating element in the standby mode.

There is even further provided in accordance with yet another preferred embodiment of the present invention apparatus for supplying heated liquid for use in cleaning a vehicle surface, including a liquid container, having an inlet through which a liquid is received from a reservoir and an outlet through which the liquid is discharged for cleaning the vehicle surface, a heating element operative to heat the liquid in the liquid container and at least one insulating portion overlying the liquid container, the at least one insulating portion including a volume maintained under a vacuum.

Preferably, the at least one insulating portion includes at least one insulating cover assembly including the volume maintained under a vacuum.
Additionally or alternatively, the apparatus also includes at least one insulation layer between the liquid container and the at least one insulating portion.

There is still further provided in accordance with a further preferred embodiment of the present invention a method for supplying heated liquid for use in cleaning a vehicle surface including providing a liquid container for heating a liquid and at least one insulating portion overlying the liquid container, the at least one insulating portion including a volume maintained under a vacuum, receiving a liquid into the liquid container, heating the liquid in the liquid container and discharging the liquid through an outlet onto a vehicle surface to be cleaned.

There is also provided in accordance with still another preferred embodiment of the present invention apparatus for de-icing a vehicle surface, including a wiper assembly including a wiper driver assembly operative to move the wiper assembly along the vehicle surface, a wiper arm, a wiper blade holder and a wiper blade, a vessel containing a liquid, at least one heating element for heating the liquid in the vessel, a controller operative to control the at least one heating element, at least one heat conductive circulation conduit adjacent to at least one of the wiper arm and the wiper blade holder and a circulation pump operative to circulate liquid from the vessel through the at least one heat conductive circulation conduit.

Preferably, the at least one of the wiper arm and the wiper blade holder is operative to travel along the vehicle surface in a first direction and in a second direction opposite the first direction, the at least one heat conductive circulation conduit includes at least one first heat conductive portion and at least one second heat conductive portion, the at least one first heat conductive portion is operative to travel along the vehicle surface in front of the wiper arm when the wiper arm moves in the first direction and in back of the wiper arm when the wiper arm moves in the second direction and the at least one second heat conductive portion is operative to travel along the vehicle surface in back of the wiper arm when the wiper arm moves in the first direction and in front of the wiper arm when the wiper arm moves in the second direction.

Preferably, the apparatus also includes at least one non heat conductive circulation conduit in fluid communication with the circulation pump and the at least one heat conductive circulation conduit. Additionally or alternatively, at least a portion of the at least one heat conductive circulation conduit is formed of a flexible material.
Preferably, the at least a portion of the at least one heat conductive circulation conduit is integrally formed with the wiper arm. Alternatively or additionally, the at least a portion of the at least one heat conductive circulation conduit is integrally formed with the wiper blade holder.

In accordance with another preferred embodiment of the present invention the apparatus also includes at least one additional heating element for directly heating at least one of at least a portion of the wiper arm and at least a portion of the wiper blade holder. Additionally, the at least one additional heating element is also operative to heat the wiper blade.

Preferably, the at least one heat conductive circulation conduit forms part of a continuous circulation path to and from the vessel.

There is still further provided in accordance with yet another preferred embodiment of the present invention a method for de-icing a vehicle surface, including providing a wiper assembly including a wiper arm, a wiper blade holder, a wiper blade and a wiper driver assembly operative to move the wiper assembly along the vehicle surface, providing at least one heat conductive circulation conduit adjacent to at least one of the wiper arm and the wiper blade holder, heating a liquid in a vessel, circulating liquid from the vessel through the at least one heat conductive circulation conduit and moving the wiper assembly along the vehicle surface.

There is even further provided in accordance with still another preferred embodiment of the present invention apparatus for supplying heated liquid for use in cleaning a vehicle surface including a vessel, having an inlet through which a liquid is received from a reservoir and an outlet through which the liquid is discharged for cleaning the vehicle surface, a heating unit operative to heat the liquid in the vessel, a dirt sensor providing a dirt level output and a controller operative to generate at least one of a non-spray indication output signal and at least two different spray indication output signals at least partially in response to the dirt level output.

Preferably, the controller is operative to compare the dirt level output to at least two different dirt level thresholds. Alternatively or additionally, the at least two different spray indication output signals include signals that generate at least two different heated spraying cycles.
Preferably, the apparatus also includes at least one additional sensor operative to provide at least one additional input to the controller and wherein the controller is also operative to base the at least two different spray indication output signals at least partially on the at least one additional input. Additionally, the at least one additional sensor includes a temperature sensor and the at least one additional input includes a temperature sensed by the temperature sensor. Alternatively or additionally, the controller is also operative to calculate at least one additional parameter and to base the at least two different spray indication output signals at least partially on the at least one additional parameter. Additionally, the at least one additional parameter includes a rate of change of the temperature sensed by the temperature sensor.

Preferably, the controller is also operative to calculate at least one additional parameter and to base the at least two different spray indication output signals at least partially on the at least one additional parameter. Additionally, the at least one additional parameter includes a rate of change of the dirt level output.

There is also provided in accordance with another preferred embodiment of the present invention a method for supplying heated liquid for use in cleaning a vehicle surface including providing a vessel for heating a liquid, receiving a liquid into the vessel, heating the liquid, measuring a dirt level adjacent the vehicle surface and providing a dirt level output and providing at least one dirt level output signal and at least two different spray indication output signals at least partially in response to the dirt level output.

There is further provided in accordance with yet another preferred embodiment of the present invention apparatus for de-icing a vehicle surface, including a wiper assembly including at least one wiper for wiping the vehicle surface, the wiper operative to move along the vehicle surface and a wiper actuator including a motor which actuates the at least one wiper and a wiper controller operative to operate the motor in at least a first operational mode and a second operational mode, the wiper controller being operative to ascertain if the at least one wiper is blocked or unblocked, to operate the motor in accordance with the first operational mode when the at least one wiper is unblocked and to operate the motor in accordance with the second operational mode when the at least one wiper is blocked.
There is yet further provided in accordance with still another preferred embodiment of the present invention a method for de-icing a vehicle-surface including providing a wiper assembly including at least one wiper for wiping the vehicle surface and a wiper actuator system including a motor which actuates the at least one wiper and a wiper controller operative to control the motor, ascertaining if the at least one wiper is blocked or unblocked, operating the motor in accordance with a first operational mode when the at least one wiper is unblocked and operating the motor in accordance with a second operational mode when the at least one wiper is blocked.

Preferably, the ascertaining includes setting a blocked threshold level, measuring an operational parameter of the wiper assembly and comparing the operational parameter to the blocked threshold level. Additionally, the blocked threshold level is a function of an angle of movement of the at least one wiper. Alternatively or additionally, the second operational mode includes setting a maximum operational level to be applied to the motor, applying an operational input less than or equal to the maximum operational level for a time interval, ascertaining, at the end of the time interval, if the at least one wiper is blocked or unblocked and if the at least one wiper is blocked, changing the direction of the at least one wiper.

Preferably, the maximum operational level is greater than the blocked threshold level. Alternatively, the maximum operational level is zero. In another alternative embodiment, the maximum operational level is less than the threshold level and the ascertaining at the end of the time interval includes measuring an operational parameter of the wiper assembly and comparing the operational parameter to the maximum operational level.

In accordance with another preferred embodiment, the second operational mode includes setting a maximum operational level to be applied to the motor, applying an operational input less than or equal to the maximum operational level for a time interval and changing the direction of the at least one wiper at the end of the time interval.

In accordance with another preferred embodiment, the second operational mode includes setting a time interval, providing rapid back and forth movement of the at least one wiper over a small area adjacent to a location of the at least one wiper when the at least one wiper becomes blocked, for the time interval, ascertaining, at the end of
the time interval, if the at least one wiper is blocked or unblocked and if the at least one wiper is blocked, changing the direction of the at least one wiper.

There is still further provided in accordance with yet another preferred embodiment of the present invention a thermal fuse including an electrical power supply connection including a first conductive portion, a second conductive portion in electrical communication with the first conductive portion, the second conductive portion being operative to melt in response to being heated above a predetermined temperature and an expanding non electrically conductive portion operative to expand and displace the second conductive portion out of electrical communication with the first conductive portion in response to heating of the second conductive portion above a predetermined temperature, thus interrupting supply of electrical power through the electrical power supply connection.

Preferably, the expanding non electrically conductive portion is operative to expand and displace the second conductive portion regardless of the orientation of the thermal fuse.

There is also provided in accordance with another preferred embodiment of the present invention a liquid collection and reuse system for use with a vehicle including at least one liquid collector associated with the vehicle and at least one collection reservoir associated with the vehicle, having an inlet through which a liquid is received from the at least one liquid collector.

Preferably, the collection reservoir includes an outlet through which the liquid is discharged for cleaning a vehicle surface. Alternatively or additionally, the liquid collection and reuse system also includes a vessel for heating the liquid, the vessel having an inlet through which a liquid is received from the collection reservoir and an outlet through which the liquid is discharged for cleaning a vehicle surface.

In accordance with another preferred embodiment the at least one liquid collector is operative to collect liquid drainage from a vehicle air conditioning unit.

In accordance with another preferred embodiment the liquid collection and reuse system also includes at least one filter operative to receive unfiltered liquid from the at least one liquid collector and to provide filtered liquid to the at least one collection reservoir. Additionally or alternatively, the liquid collection and reuse system also includes at least one pre-filtration valve. Additionally, the liquid collection and
reuse system also includes a drain and the at least one pre-filtration valve is operative in
a filter open position to allow unfiltered liquid to reach the at least one filter and in a
filter closed position directs unfiltered liquid to the drain.

In accordance with another preferred embodiment the liquid collection
and reuse system also includes a liquid flow controller operative to control a liquid flow
based on a liquid level sensed by a liquid level sensor. Additionally, the liquid
collection and reuse system also includes a vehicle reservoir operative to supply liquid
to a liquid heating unit and the liquid level sensor measures a liquid level within the
vehicle reservoir and the liquid flow controller is operative to provide liquid to the
vehicle reservoir based on the liquid level sensed by the liquid level sensor.

In accordance with another preferred embodiment the liquid collection
and reuse system also includes at least one additional reservoir and a liquid flow
controller operative to control multiple liquid flows through the liquid collection and
reuse system. Additionally, a liquid in the at least one additional reservoir is a different
liquid than a liquid in the at least one collection reservoir. Additionally, the liquid flow
controller is operative to provide an optimal mix of liquids from the at least one
collection reservoir and the at least one additional reservoirs. Alternatively, the at least
one additional reservoir and the at least one collection reservoir contain the same liquid.

There is further provided in accordance with still another preferred
embodiment of the present invention a method for liquid collection and reuse including
collecting liquid utilizing at least one liquid collector associated with a vehicle and
receiving the liquid into at least one collection reservoir located in the vehicle.

Preferably, the method also includes discharging the liquid through an
outlet onto a vehicle surface to be cleaned. Additionally or alternatively, the method
also includes filtering the liquid prior to the receiving.

There is still further provided in accordance with yet another preferred
embodiment of the present invention apparatus for supplying heated liquid for use in
cleaning a vehicle surface, including a vessel, having an inlet through which a liquid is
received from a reservoir and an outlet through which the liquid is discharged for
cleaning the vehicle surface, the vessel including a rounded end portion, a heat transfer
cover operative to heat the liquid, the heat transfer cover including a curved cross
section portion formed on an inner facing surface thereof, the curved cross section
portion including multiple protruding sections each including a curved portion and a heating element adjacent the heat transfer cover operative to heat the heat transfer cover.

Preferably, the rounded end portion, the curved cross section portion and the curved portions of the heat transfer cover provide for liquid circulation within the vessel that generates improved heat transfer from the heat transfer cover to the liquid contained in the vessel. Additionally or alternatively, the rounded end portion, the curved cross section portion and the curved portions of the heat transfer cover provide for liquid circulation within the vessel that generates improved uniformity of the temperature of the liquid contained in the vessel.

Preferably, the rounded end portion, the curved cross section portion and the curved portions of the heat transfer cover generate a generally circular flow within the vessel at a first temperature differential between the liquid contained within the vessel and portions of the heat transfer cover in contact with the liquid. Additionally or alternatively, the rounded end portion the curved cross section portion and the curved portions of the heat transfer cover generate multiple generally circular flows within the vessel at a second temperature differential between the liquid contained within the vessel and portions of the heat transfer cover in contact with the liquid.

There is also provided in accordance with yet another preferred embodiment of the present invention a method for supplying heated liquid for use in cleaning a vehicle surface, including providing a vessel for heating a liquid, the vessel including a rounded end portion, receiving a liquid into the vessel so that the liquid flows into the rounded end portion, heating a heat transfer cover overlying the vessel thereby heating the liquid in the rounded end portion through the heat transfer cover, the heat transfer cover including a curved cross section portion formed on an inner facing surface thereof, the curved cross section portion including multiple protruding sections each including a curved portion and discharging the liquid through an outlet onto the vehicle surface.

There is further provided in accordance with still another preferred embodiment of the present invention apparatus for de-icing a vehicle surface, including a wiper assembly including a wiper driver assembly operative to move the wiper assembly along the vehicle surface a wiper arm, a wiper blade holder and a wiper blade
and at least one heating element for directly heating at least one of at least a portion of the wiper arm and at least a portion of the wiper blade holder.

Preferably, the at least one heating element is also operative to heat the wiper blade.

Preferably, the apparatus also includes a controller operative to control the at least one heating element.

There is yet further provided in accordance with another preferred embodiment of the present invention a method for de-icing a vehicle surface, including providing a wiper assembly including a wiper arm, a wiper blade holder, a wiper blade and a wiper driver assembly operative to move the wiper assembly along the vehicle surface, heating at least one of at least a portion of the wiper arm and at least a portion of the wiper blade holder and moving the wiper assembly along the vehicle surface.

There is still further provided in accordance with yet another preferred embodiment of the present invention apparatus for supplying heated liquid for use in cleaning a vehicle surface including a vessel, having an inlet through which a washing fluid is received from a reservoir and an outlet through which the fluid is discharged for cleaning the vehicle surface, a heating element for heating the fluid in the vessel, a controller for controlling operation of the apparatus and an RF actuator in communication with the controller, the RF actuator operative to initiate communication with the controller and to uniquely identify the RF actuator to the controller.

Preferably, the controller is operative, upon receipt of a standby mode actuation from the RF actuator, to operate the apparatus in accordance with a heating element standby mode. Additionally or alternatively, the controller is operative, upon receipt of an automatic mode actuation from the RF actuator, to operate the apparatus in accordance with an automatic mode. Alternatively or additionally, the controller is operative, upon receipt of an off command from the RF actuator, to place the apparatus in an off mode.

Preferably, the controller is operative to ignore commands from the RF actuator when an engine of the vehicle is in an off state. Additionally, the controller is operative to monitor the state of the engine of the vehicle by measuring a voltage level of a battery of the vehicle. Additionally, the vehicle is in an off state when the voltage level is less than a predetermined level.
There is also provided in accordance with another preferred embodiment of the present invention apparatus for supplying heated liquid for use in cleaning a vehicle surface including a vessel, having an inlet through which a liquid is received from a reservoir and an outlet through which the liquid is discharged for cleaning the vehicle surface and a heating element operative to heat the liquid in the vessel, at least a portion of the vessel being formed of rubber.
BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and appreciated more fully from the following detailed description, taken in conjunction with the drawings in which:

Figs. IA and IB are simplified pictorial illustrations of vehicle headlight cleaning and de-icing systems constructed and operative in accordance with preferred embodiments of the present invention installed in a vehicle;

Fig. 2 is a simplified exploded view pictorial illustration of the heating unit of the system of Figs. IA and IB;

Fig. 3A is a front view of the heating unit of the system of Figs. IA and IB;

Fig. 3B is a sectional view of the heating unit of the system of Figs. IA and IB taken along lines HIB-IIIB of Fig. 3A;

Fig. 4A is an overhead view of the heating unit of Figs. IA - 3B;

Fig. 4B is a front view of the heating unit of Figs. IA - 3B without the first insulating cover;

Figs. 5A and 5B are respective front and back views of the heat transfer cover of the heating unit of Figs. IA - 4B;

Fig. 6 is a simplified pictorial illustration of the vessel of the heating unit of Figs. IA - 5B illustrating the liquid flow therethrough;

Fig. 7 is a simplified diagram of the circulating liquid flows within the primary heating chamber of the heating unit of Figs. IA - 6;

Fig. 8 is a simplified flow chart of a preferred mode of operation of the system of Figs. IA - 7 including an immediate spray mode, a high temperature spray mode and a standby mode;

Figs. 9A and 9B are simplified flow charts of a preferred embodiment of the immediate spray mode and the high temperature spray mode, respectively, of Fig. 8;

Fig. 10 is a simplified schematic illustration of a liquid collection and reuse system for use in a vehicle in accordance with a preferred embodiment of the present invention;
Fig. 11 is a simplified schematic illustration of a liquid collection and reuse system for use in a vehicle in accordance with another preferred embodiment of the present invention;

Fig. 12 is a simplified pictorial illustration of a vehicle windshield cleaning and de-icing system constructed and operative in accordance with another preferred embodiment of the present invention installed in a motor vehicle;

Fig. 13 is a simplified sectional illustration of a vessel for heating liquid which may form part of the vehicle windshield cleaning and de-icing system of Fig. 12;

Fig. 14 is a simplified flow chart of a method for ascertaining a 'near-boiling temperature' of a liquid for use in the vehicle windshield cleaning and de-icing system of Figs. 12 - 13;

Fig. 15 is a simplified flow chart of a preferred mode of operation of the system of Figs. 12 - 13;

Fig. 16 is a simplified exploded view illustration of another vessel for heating liquid which may form part of the vehicle windshield cleaning and de-icing system of Fig. 12;

Fig. 17 is a simplified pictorial illustration of a windshield wiper assembly for use in a vehicle, constructed and operative in accordance with yet another preferred embodiment of the present invention;

Figs. 18A and 18B are simplified pictorial illustrations of two alternative circulation flows for circulating liquid adjacent to the windshield wiper assembly of Fig. 17;

Fig. 19 is a simplified pictorial illustration of the wiper arm of the windshield wiper assembly of Fig. 17;

Fig. 20 is a simplified pictorial illustration of a windshield wiper assembly for use in a vehicle, constructed and operative in accordance with yet another preferred embodiment of the present invention; and

Fig. 21 is a simplified flowchart of a method for operating a windshield wiper assembly in accordance with another preferred embodiment of the present invention, particularly useful with the windshield wiper assemblies described hereinabove with reference to Figs. 17 - 20.
DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

It is appreciated that the term "vehicle" as used in the context of the present patent application and in the claims can refer to any type of wheeled vehicle having windows or any other interior or exterior surface requiring cleaning and/or de-icing, such as an automobile or a truck, as well as a boat or an airplane.

It is also appreciated that, even though the present invention is shown in the context of either a headlight or a windshield cleaning and de-icing system, the systems and methods of the present invention can be utilized to clean and/or de-ice any interior or exterior vehicle surface including, for example, front and/or rear windshields, mirrors, windows, headlights, tail lights, radar, radome. It is further appreciated that the cleaning and de-icing system of the present invention may also be used to clean and/or de-ice any vehicle surface that transmits or receives energy, such as, but not limited to, visible light, infrared light, RF energy and UV energy.

It is appreciated that the terms "cleaning" and "de-icing" as used in the context of the present patent application and in the claims are used interchangeably to refer to apparatus, systems and methods for removing ice, snow and/or any other foreign matter from vehicle interior or exterior surfaces requiring cleaning and/or de-icing.

It is further appreciated that the term "standby mode", as used in context of the present patent application and in the claims, refers to operation of a vehicle liquid heating system that includes functionality whereby a quantity of liquid in the vessel may be heated prior to an operator-generated or automatically-generated request for heated liquid discharge, such as spraying. Additionally, the term "reservoir standby mode", as used in context of the present patent application and in the claims, refers to a vehicle liquid heating system including functionality whereby a quantity of liquid in a liquid reservoir of the vehicle may be heated prior to an operator-generated or automatically-generated request for heated liquid discharge.

It is appreciated that the term "controller", as used in context of the present patent application and in the claims, may refer to a controller which forms part of the vehicle liquid heating system of the present invention, or to a vehicle computer or...
computers or to any combination thereof. The controller may be in communication with a vehicle computer or computers and one or more sensors, as described further hereinbelow.

It is appreciated that the term "primary temperature sensor" as used in the context of the present patent application and in the claims, refers to at least one temperature sensor that provides information to a controller relating to at least one temperature for which an upper and/or lower threshold is established. The "primary temperature sensor" is thus operative to indicate at least one temperature for which the threshold has been established. The temperature sensor or sensors which comprise the "primary temperature sensor" may vary depending on the operating mode of the system, as described further hereinbelow, for example, in reference to Figs. 14 - 16.

The controller of the present invention is operative, in a plurality of operating modes, to control the heating and/or discharge of liquid based on at least one threshold, which may be predetermined or set on a 'real-time' basis. It is appreciated that the at least one threshold may be a function of information received from one or more sensors communicating with the controller, such as an interior or exterior vehicle mounted sensor, a sensor not located in or on the vehicle that is in wireless communication with the controller, as described further hereinbelow.

It is appreciated that the terms "non heat conductive material" and "heat conductive material" as used in the context of the present patent application and in the claims, refers to materials which are known in the art to be relatively poor heat conductors and relatively good heat conductors, respectively.

It is appreciated that the terms "non electrically conductive material" and "electrically conductive material" as used in the context of the present patent application and in the claims, refers to materials which are known in the art to be relatively poor conductors of electricity and relatively good conductors of electricity, respectively.

Reference is now made to Fig. IA, which is a simplified pictorial illustration of a headlight cleaning and de-icing system constructed and operative in accordance with a preferred embodiment of the present invention. As seen in Fig. IA, an otherwise conventional motor vehicle 100 is seen to incorporate a headlight cleaning and de-icing system 102.
The headlight cleaning and de-icing system 102 preferably includes a liquid reservoir 106, which contains liquid, such as water or windshield cleaning liquid. Preferably, a pump 108 supplies the liquid to a liquid heating unit 110 through a liquid inflow conduit 112. Liquid from liquid heating unit 110 is discharged via a liquid outflow conduit 116 and liquid spray supply conduits 118 which supply liquid to sprayers 120 located adjacent to vehicle headlights 122. Preferably, wipers 126 are located in front of headlights 122 to wipe liquid and clean or de-ice vehicle headlights 122.

In accordance with a preferred embodiment of the present invention, each of vehicle headlights 122 is equipped with a conventional dirt sensor 128. One embodiment of such a conventional dirt sensor is described in U.S. Patent 4,224,551.

Liquid heating unit 110 is connected via electric cables 130 to a vehicle battery 132. A preferred embodiment of liquid heating unit 110, described hereinbelow with reference to Figs. 2 - 7, is preferably positioned within the vehicle, with liquid inflow conduit 112 entering from the bottom of liquid heating unit 110 and liquid outflow conduit 116 exiting from the top of liquid heating unit 110, along a vertical axis shown by arrow 134, generally perpendicular to the plane defined by the vehicle's wheel axles. It is appreciated, however, that the liquid heating unit 110 of Figs. 2 - 7 may be installed in any direction within the vehicle.

Alternatively, liquid heating unit 110 may be any liquid heating device suitable for use in a vehicle, including but not limited to those described in applicants'/assignee's U.S. Patent Nos. 6,164,564; 6,615,438; 6,669,105; 6,892,417 and 7,108,754, applicants'/assignee's U.S. Patent Application Nos. 11/203,779; 10/700,141; 10/477,486 and 10/531,979 and applicants'/assignee's PCT Application Serial No. PCT/IL2005/00179, the disclosures of which are hereby incorporated by reference.

It is appreciated that even though the illustrated embodiment shows a separate reservoir 106, headlight cleaning and de-icing system 102 may utilize an existing vehicle reservoir (not shown) to provide liquid to liquid heating unit 110.

An actuator panel 140 is typically located on the vehicle dashboard and includes an actuator (not shown) in communication with a headlight cleaning and de-icing system controller 150. The headlight cleaning and de-icing system controller 150 is also preferably connected to an existing vehicle computer (not shown). The actuator
panel 140 preferably includes at least two operator actuator buttons, a first actuator button for actuating operation in an immediate spray mode and a second actuator button for actuating operation in a high temperature spray mode. Alternatively, these two functionalities may be included in a single operator actuator button having multiple actuation functionalities.

In accordance with a preferred embodiment of the present invention, actuator panel 140 is in RF communication, preferably wireless RF communication, with controller 150 and/or the vehicle computer. Alternatively, actuator panel 140 may be in wired communication with controller 150 and/or the vehicle computer. In another alternative embodiment, actuator panel 140 may be obviated and a portable actuator in RF communication with controller 150 and/or the vehicle computer may be provided.

In the illustrated embodiment, actuator panel 140 includes three actuation buttons 152, 154 and 156. Typically, actuation button 152 is assigned to a standby mode functionality, actuation button 154 is assigned to an automatic mode functionality, such as a high temperature spray mode functionality, and actuation button 156 is assigned to an off functionality.

Actuator 140 also preferably includes multiple LED indicators to provide system status information to the operator of the vehicle. In the illustrated embodiment a Standby Mode LED 160 and an Automatic Mode LED 162 are included.

It is appreciated that the system of the present invention may either be installed as part of the window washing system in a new automobile, or it may be retrofitted into an existing washing system.

It is also appreciated that liquid heating unit 110 and pump 108 are preferably in electrical communication with the headlight cleaning and de-icing system controller 150 and/or with the vehicle computer. It is additionally appreciated that the headlight cleaning and de-icing system controller 150 is preferably in electrical communication with the vehicle computer. Alternatively, the functionality of the headlight cleaning and de-icing system controller 150 may be included in the vehicle computer and a separate headlight cleaning and de-icing system controller 150 may be obviated.

Dirt sensor 128 is preferably in communication with the headlight cleaning and de-icing system controller 150 and/or the existing vehicle computer. In
accordance with a preferred embodiment of the present invention, dirt sensor 128 is operative to transmit a sensed dirt indication to the headlight cleaning and de-icing system controller 150 or to the vehicle computer. The headlight cleaning and de-icing system controller 150 or the vehicle computer is operative to ascertain if the extent of dirt sensed by dirt sensor 128 exceeds a first threshold and, if so to transmit a first control signal to pump 108, such as a control signal to provide a discharge of liquid after a predetermined interval. The headlight cleaning and de-icing system controller 150 or the vehicle computer is also operative to ascertain if the extent of dirt sensed by dirt sensor 128 exceeds a second threshold and, if so to transmit a second control signal to pump 108, such as a control signal to provide an immediate discharge of liquid.

In accordance with a preferred embodiment of the present invention, the headlight cleaning and de-icing system controller 150 and/or the vehicle computer is operative to provide a liquid discharge cycle based on inputs received from the dirt sensor and may additionally utilize one or more inputs. It is appreciated that the liquid discharge cycle may be initiated immediately or may be initiated after a suitable period during which liquid in the liquid heating unit is heated. It is also appreciated that any or all of the discharge modes described hereinbelow with reference to Figs. 8 - 9B may be employed in association with the functionality described hereinabove and shown in Fig. IA.

It is appreciated that the headlight cleaning and de-icing system controller 150 and/or the vehicle computer may also receive additional inputs, such as a temperature sensed by a temperature sensor (not shown) included in liquid heating unit 110, or a temperature sensed by a temperature sensor (not shown) adjacent headlights 122 or adjacent any other vehicle surface to be cleaned and/or de-iced. Additional parameters may be calculated by the headlight cleaning and de-icing system controller 150 or the vehicle computer, such as a rate of change of the extent of dirt sensed by dirt sensor 128, and/or a rate of change of the temperature sensed by one or more temperature sensors.

Reference is now made to Fig. IB, which is a simplified pictorial illustration of a headlight cleaning and de-icing system constructed and operative in accordance with another preferred embodiment of the present invention. The embodiment of Fig. IB is similar to the embodiment of Fig. IA, except that in the
embodiment of Fig. IB headlight cleaning and de-icing system 102 includes multiple liquid heating units 110, each supplying liquid to one or more sprayers 120 located adjacent vehicle surfaces to be cleaned and/or de-iced, such as vehicle headlights 122.

As seen in Fig. IB, this embodiment, headlight cleaning and de-icing system 102 preferably includes multiple pumps 108, each supplying liquid to one or more heating units 110 from reservoir 106 through multiple liquid inflow conduits 112. It is appreciated that, even though in the illustrated embodiment of Fig. IB a single reservoir 106 is provided, multiple reservoirs 106 may also be provided. Liquid from liquid heating units 110 then flows through multiple liquid spray supply conduits 118 which supply liquid to sprayers 120 located adjacent to vehicle headlights 122. Preferably, wipers 126 are located in front of headlights 122 to wipe liquid and clean or de-ice vehicle headlights 122.

As seen further in Fig. IB, multiple dirt sensors 128 are preferably operative to send individually recognizable signals to the headlight cleaning and de-icing system controller 150. It is appreciated that liquid heating units 110 and pumps 108 are preferably in electrical communication with the headlight cleaning and de-icing system controller 150 and/or the vehicle computer. It is also appreciated that the headlight cleaning and de-icing system controller 150 is preferably in electrical communication with the vehicle computer. Alternatively, the functionality of the headlight cleaning and de-icing system controller 150 may be included in the vehicle computer and the headlight cleaning and de-icing system controller may be obviated.

In accordance with a preferred embodiment of the present invention, the headlight cleaning and de-icing system controller 150 and/or the vehicle computer is operative to provide a liquid discharge cycle based on inputs received from at least one of the dirt sensors 128 and may additionally utilize one or more inputs, as described hereinabove with reference to Fig. IA. It is appreciated that the liquid discharge cycle may be initiated immediately or may be initiated after a suitable period during which liquid in the liquid heating unit is being heated. It is also appreciated that any or all of the discharge modes described hereinbelow with reference to Figs. 8 - 9B may also be employed together with the functionality described hereinabove and shown in Fig. IB.

It is appreciated that in the embodiment of Fig. IB, the headlight cleaning and de-icing system controller 150 is preferably operative, in response to an
input signal received from a single dirt sensor 128 to activate only the specific liquid heating unit 110 and/or pump 108 corresponding to the dirt sensor 128 that generated the input signal. Alternatively, multiple heating units 110 and/or multiple pumps 108 may be activated in response to a heated discharge actuation generated by an input received from a single dirt sensor 128.

Reference is now made to Fig. 2, which is a simplified exploded view pictorial illustration of a preferred liquid heating unit suitable for use with the headlight cleaning and de-icing system of the present invention, and to Figs. 3A, 3B, 4A, 4B, 5A and 5B, which illustrate parts of the heating unit of Fig. 2. As seen in Fig. 2, liquid heating unit 110 preferably includes a first thermal insulating cover assembly 200, an electrical contact portion 204, a heating element 206, a liquid container 208 including a heat transfer element, such as a heat transfer cover 210, and at least one enclosing element, such as a vessel 212, an insulating cover connection frame 216 and a second thermal insulating cover assembly 220.

First thermal insulating cover assembly 200 preferably includes an outer portion 230 and an inner portion 232, both preferably formed of stainless steel and welded together around an outer edge 234 to seal the interior thereof from the outside. A volume 236, defined between outer portion 230 and inner portion 232, is preferably maintained under vacuum to enhance thermal insulation.

Electrical contact portion 204 preferably includes controller 150 comprising a printed circuit board 240 in electrical contact with wires 242 connected via electric cables 130 (Fig. 1A) to vehicle battery 132 (Fig. 1).

Heating element 206 is preferably a resistance type heater, and preferably is connected at a positive terminal 250 thereof to printed circuit board 240 via a wire 252. An outer surface 254 of heating element 206 is preferably formed of a heat conductive material.

The heat transfer element of liquid container 208, such as the heat transfer cover 210 of the illustrated embodiment, is preferably formed of aluminum or any other suitable heat conducting material. Heat transfer cover 210 preferably includes, on an outer facing surface 256 thereof, a heating element holder 260 into which heating element 206 is placed, forming an electrical connection with a negative terminal of heating element 206. A plurality of spacers 264 is preferably formed on outer facing
surface 256. Printed circuit board 240 is preferably attached to spacers 264.

As seen particularly in Figs. 3B and 5B, an inner facing surface 266 of heat transfer cover 210 is preferably formed with a portion 268, including a curved cross section, including multiple protruding sections 270, each preferably also formed with a curved portion 272.

The at least one enclosing element of liquid container 208, such as vessel 212 of the illustrated embodiment, is preferably formed of rubber, molded plastic or any other suitable non-heat conductive material and preferably includes a first heating chamber, such as primary heating chamber 280, and a second heating chamber, such as secondary heating chamber 282. Alternatively, the vessel 212 may be formed of a heat conductive material. In a preferred embodiment of the present invention, vessel 212 includes at least one flexible wall portion, preferably formed of rubber or any other suitable material, to avoid breakage of vessel 212 due to expansion and contraction caused by freezing of liquid within. In another alternative embodiment, liquid container 208 may be integrally formed of any suitable heat conductive material.

It is appreciated that, although in the illustrated embodiment the heat transfer cover 210 defines a single external wall of liquid container 208, the heat transfer element of the present invention may be any suitably configured element, defining at least a portion of at least one external wall of liquid container 208 and being in direct thermal contact with first and second heating chambers located therein and with the heating element 206. For example, in an alternative embodiment, vessel 212 may be formed of a heat conductive material, cover 210 may be formed of a non-heat conductive material and heating element 206 may be located adjacent an external surface of vessel 212.

A wall 284, separating primary heating chamber 280 and secondary heating chamber 282, preferably is formed with notches 288 at ends thereof to allow for fluid communication between primary heating chamber 280 and secondary heating chamber 282. Secondary heating chamber 282 is preferably formed with a liquid inflow connector aperture 290 in fluid communication with reservoir 106 through liquid inflow conduit 112. Primary heating chamber 280 is preferably formed with a liquid outflow connector aperture 292 in fluid communication with sprayers 120 through liquid outflow conduit 116 and liquid spray supply conduits 118.
In the embodiment of Fig. IB, liquid outflow connector aperture 292 is preferably in fluid communication with sprayers 120 via liquid spray supply conduits 118. Liquid inflow connector aperture 290 and liquid outflow connector aperture 292 are preferably threaded for insertion of a connector thereinto.

Primary heating chamber 280 is preferably formed as a single cavity 294 to accommodate multiple protruding sections 270 of heat transfer cover 210. As seen in Fig. 3B, cavity 294 is preferably rounded at an end 296 opposite heat transfer cover 210. As described hereinbelow with reference to Fig. 6, secondary heating chamber 282 preferably includes multiple wall portions 298 of varying lengths to facilitate liquid flow through secondary heating chamber 282. Multiple wall portions 298 are preferably located in a direction generally parallel to wall 284.

Heat transfer cover 210 is preferably connected to vessel 212 using screws (not shown) to provide a liquid tight seal.

Insulating cover connection frame 216 is preferably formed of rubber, molded plastic or any other suitable non heat conductive material, and is operative to seal together first thermal insulating cover assembly 200 and second thermal insulating cover assembly 220. Frame 216 also includes a wire insertion aperture 300, a liquid inflow aperture 302 and a liquid outflow aperture 304.

Second thermal insulating cover assembly 220 preferably includes an outer portion 330 and an inner portion 332, preferably formed of stainless steel, welded together around an outer edge 334 and sealed to enable a vacuum to be maintained in a volume 336 therebetween.

As seen particularly in Fig. 3B, liquid heating unit 110 also includes liquid inlet connector 340 and liquid outlet connector 342 which are connected to liquid inflow conduit 112 (Fig. IA) and liquid outflow conduit 116 (Fig. IA) respectively. In the embodiment of Fig. IB, liquid outlet connector 342 is connected to liquid spray supply conduit 118.

Liquid heating unit 110 also preferably includes a first temperature sensor 350 in contact with heat transfer cover 210 and a second temperature sensor 352 in contact with the liquid in secondary heating chamber 282. First temperature sensor 350 alternatively may be in contact with the liquid in primary heating chamber 280. First temperature sensor- 350 and second temperature sensor 352 are preferably in
electrical connection with controller 150.

Controller 150 is preferably operative to provide functionality as described hereinbelow with reference to Figs. 8 - 9B and Figs. 14 - 15.

As seen particularly in Fig. 3B, in accordance with a preferred embodiment of the present invention, liquid heating unit 110 also preferably includes a thermal fuse 360 operative to disconnect electric power from heating element 206 in response to overheating of the liquid heating unit 110, typically caused by lack of liquid in liquid container 208. Thermal fuse 360 is connected to heat transfer cover 210, preferably by a screw end 362 formed in a first conductive portion 364 thereof, preferably formed of copper or other suitable heat conductive and electrically conductive material. Thermal fuse 360 also includes a non electrically conductive portion 366, preferably formed of a non electrically conductive material, typically plastic, such as ULTEM® 1000, manufactured by General Electric Company, Fairfield, CT 06828, USA, and a second conductive portion 368, preferably formed of a heat conductive and electrically conductive material, such as solder or other suitable material. Non electrically conductive portion 366 and second conductive portion 368 are configured to position an end 370 of an electrical wire 372. An opposite end 374 of electrical wire 372 is connected to printed circuit board 240.

Thermal fuse 360 is operative to provide overheating protection, when in contact with any heated surface, such as heat transfer cover 210, at a predetermined temperature. The predetermined temperature is a function of the melting temperature of second conductive portion 368. In the event of overheating, non electrically conductive portion 366 expands and causes melted second conductive portion 368 to be displaced out of electrical contact with conductive portion 364, thereby disconnecting wire 372 from first conductive portion 364.

It is appreciated that preferably the expansion of non electrically conductive portion 366 does not provide ample force to displace second conductive portion 368 until second conductive portion 368 has begun to melt. Preferably thermal fuse 360 is operative as described hereinabove irrespective of the orientation of thermal fuse 360 relative to gravity. It is appreciated that after second conductive portion 368 has been displaced, non electrically conductive portion 366 prevents end 370 of wire 372 from making electrical contact with first conductive portion 364, irrespective of the
orientation of thermal fuse 360.

It is appreciated that thermal fuse 360 may be utilized to provide overheating protection in conjunction with any heated surface. Additionally, thermal fuse 360 may be utilized in any heated volume, such as a volume of heated gas, to provide electrical disconnect in the event of overheating.

A preferred method for the assembly of liquid heating unit 110 is now described.

First thermal insulating cover assembly 200 is preferably formed by welding outer portion 230 and inner portion 232 around outer edge 234, evacuation of the volume therebetween and sealing thereof, as described hereinabove. Second thermal insulating cover assembly 220 is preferably formed by welding outer portion 330 and inner portion 332 around outer edge 334, evacuation of the volume therebetween and sealing thereof, as described hereinabove.

Liquid container 208 is formed by attaching heat transfer cover 210 to vessel 212 using screws (not shown) and screw holes provided. Printed circuit board 240 is preferably attached to spacers 264 on heat transfer cover 210. Heating element 206 is preferably inserted into heating element holder 260 and is preferably connected to printed circuit board 240 via wire 252.

Second thermal insulating cover assembly 220 is partially filled with a layer of insulating material 400, preferably plastic foam, and then sealed to insulating cover connection frame 216. Liquid container 208, including vessel 212 and heat transfer cover 210, with heating element 206 and electrical contact portion 204 attached thereto, is then inserted into insulating cover connection frame 216 with wires 242 inserted through wire insertion aperture 300. Liquid inlet connector 340 is then preferably inserted through liquid inflow aperture 302 and is sealingly connected to liquid inflow connector aperture 290. Liquid outlet connector 342 is then preferably inserted through liquid outflow aperture 304 and is sealingly connected to liquid outflow connector aperture 292. An additional layer of insulating material 404, preferably plastic foam, is then inserted above liquid container 208, and first thermal insulating cover assembly 200 is then sealed to insulating cover connection frame 216.

It is appreciated that, although in the illustrated embodiment of Figs. 1A - 5B heating element 206 is located external to liquid container 208, in an alternative
embodiment (not shown) a heating element may be located internally to a liquid container, such as liquid container 208 or any other suitable liquid container.

It is appreciated that the first and/or second insulating covers and/or the insulating material described hereinabove can be used with any suitable liquid heating unit, including but not limited to those described in applicants'/assignee's U.S. Patent Nos. 6,164,564; 6,615,438; 6,669,105; 6,892,417 and 7,108,754, applicants'/assignee's U.S. Patent Application Nos. 11/203,779; 10/700,141; 10/477,486 and 10/531,979 and applicants'/assignee's PCT Application Serial No. PCT/IL2005/00179, the disclosures of which are hereby incorporated by reference.

It is also appreciated that, although in the illustrated embodiment of Figs. 1A - 5B first thermal insulating cover assembly 200 and second thermal insulating cover assembly 220, together with the insulating cover connection frame 216, enclose the entire liquid container 208, either first thermal insulating cover assembly 200 or second thermal insulating cover assembly 220 or both may be obviated and a suitable thermal insulating cover, preferably including a volume maintained under vacuum, covering only a portion of liquid container 208, such as, for example, an insulating cover covering the area of heating element 206, may be provided.

Reference is now made to Fig. 6, which is a simplified pictorial illustration of the vessel of the heating unit of Figs. 1A - 5B illustrating the liquid flow therethrough. As seen in Fig. 6, liquid enters vessel 212 through liquid inflow connector aperture 290, as shown by arrow 450, and enters secondary heating chamber 282. Liquid flows between multiple wall portions 298 through notches 288 in wall 284, as shown by arrows 452, and into primary heating chamber 280. Liquid then flows through primary heating chamber 280, as shown by arrows 456, and through liquid outflow connector aperture 292, as shown by arrow 458. It is appreciated that the liquid flows described above are driven by operation of pump 108.

It is appreciated that, as seen in Figs. 2 - 6, heating element 206 is located outside of liquid container 208 and therefore is not in contact with the liquid contained therein.

Reference is now made to Fig. 7, which is a simplified diagram of the circulating liquid flows within the primary heating chamber 280 of the heating unit of Figs. 1A - 6. As seen in Fig. 7, liquid primarily flows in cavity 294 in an outer circular
flow indicated by arrows 500 and inner circular flows indicated by arrows 502 and 504. The outer circular flow indicated by arrows 500 and the inner circular flows indicated by arrows 502 and 504 are primarily driven by the temperature differential between the liquid contained within cavity 294 and the portions of heat transfer cover 210 in contact with the liquid contained within cavity 294. It is appreciated that the flows indicated by arrows 500, 502 and 504 are a function of the curvature of portion 268, curved portion 272 and end 296.

In tests and simulations performed by the Applicants, the Applicants found that as the temperature differential between the liquid in cavity 294 and portions of heat transfer cover 210 in contact with the liquid approaches approximately 15°C, the liquid circulates primarily in a singular outer circular flow indicated by arrows 500 throughout cavity 294. As the temperature differential between the liquid in cavity 294 and portions of heat transfer cover 210 in contact with the liquid approaches approximately 25°C, the inner liquid flow changes to form inner circular flows indicated by arrows 502 and 504.

It is appreciated that the flows indicated by arrows 500, 502 and 504 described hereinabove with reference to Fig. 7 provide enhanced uniformity in heating of the liquid within cavity 294 and enhanced heat transfer from heat transfer cover 210 to liquid contained within cavity 294. It is further appreciated that the flows indicated by arrows 500, 502 and 504 described above in reference to Fig. 7 are present when the liquid heating unit is placed in a vehicle in the preferred orientation along axis 134 as shown in Fig. IA.

It is appreciated that the liquid flows indicated by arrows 500, 502 and 504 described above with reference to Fig. 7 occur in the vessel 212 even when pump 108 is not activated and the temperature of the liquid in vessel 212 is less than the temperature of heat transfer cover 210.

Reference is now made to Fig. 8, which is a simplified flow chart of a preferred mode of operation of the system of Figs. IA - 7, including an immediate spray mode, a high temperature spray mode and a standby mode, and to Figs. 9A and 9B, which are simplified flow charts of an immediate spray mode and a high temperature spray mode, respectively.

As seen in Fig. 8, controller 150 is operative to periodically check if the
vehicle ignition has been turned on, typically every 50 msec. Once controller 150
detects that the vehicle ignition is turned on, it then periodically, typically every 50
msec, checks if the engine voltage is greater than a minimum voltage, MINv, typically
12v. Controller 150 may also be operative to ensure that other vehicle parameters are
within predetermined ranges.

When the controller 150 detects that the ignition is on and that the
minimum voltage threshold has been met, controller 150 is preferably operative to
control the operation of heating element 206 in accordance with a standby mode based
on predetermined standby threshold temperatures, as described further hereinbelow. As
seen in Fig. 8, the standby mode preferably provides a recurring cycle of operations
until the vehicle ignition is turned off.

Alternatively, controller 150 may be operative in a standby mode only
upon receiving a standby actuation signal from a vehicle operator and until an off signal
is received from a vehicle operator. It is appreciated, in this embodiment, that upon
receiving the standby actuation signal from the vehicle operator, controller 150 is
operative to ensure that the ignition is on and that the minimum voltage threshold has
been met before operating in the heating element standby mode. Controller 150 may
also be operative to ensure that other vehicle parameters are within predetermined
ranges before operating in the standby mode.

In accordance with the embodiment of Fig. 8, controller 150 is operative,
when operating in standby mode, to check if operation in an immediate spray mode has
been actuated, such as by operator actuation or in response to a signal received from dirt
sensor 128 or any other sensor.

If immediate spray mode has been actuated, controller 150 is operative to
actuate pump 108 in accordance with an immediate spray mode, such as the immediate
spray mode described hereinbelow with reference to Fig. 9A or any other suitable
immediate spray mode. If immediate spray mode has not been actuated, controller 150
is operative to check if high temperature spray mode has been actuated, such as by
operator actuation or in response to a signal received from dirt sensor 128 or any other
sensor.

If high temperature spray mode has been actuated, controller 150 is
operative to control the actuation of heating element 206 and pump 108 in accordance
with a high temperature spray mode, such as the high temperature spray mode described hereinbelow with reference to Fig. 9B or any other suitable high temperature spray mode. If high temperature spray mode has not been actuated, the controller 150 is operative to check if the temperature sensed by temperature sensor 350 is less than a minimum temperature for standby mode, MINs, typically 50°C. If the temperature sensed by temperature sensor 350 is less than MINs, the controller 150 is operative to turn on heating element 206. The controller 150 is then operative to check if the temperature sensed by temperature sensor 350 is greater than a maximum temperature for standby mode, MAXs, typically 57°C. If the temperature sensed by temperature sensor 350 exceeds MAXs, the controller 150 is operative to turn off heating element 206.

As seen in the illustrated embodiment of Fig. 9A, when an immediate spray mode is actuated, the controller 150 is operative to actuate pump 108 to provide a first spray, for a first spray duration T_{IS_1}, typically a short duration such as 0.3-0.4 seconds. It is appreciated that the controller 150 will actuate pump 108 to provide the first spray regardless of the temperature of the liquid in liquid container 208. In the immediate mode of the illustrated embodiment, the first spray is followed by a waiting period of duration Tiw, preferably about 7 seconds, and a second spray, for a second spray duration T_{IS_2}, typically of a longer duration than the first spray, preferably about 1 second.

It is appreciated that the immediate spray mode seen in the illustrated embodiment of Fig. 9A is for illustrative purposes only and that controller 150 may be operative to actuate pump 108 to provide any other suitable immediate spray mode.

The system is operative to provide the first spray and the second spray of the immediate spray mode by activating pump 108 to provide liquid through liquid inflow conduit 112 into secondary heating chamber 282 which causes liquid to flow from secondary heating chamber 282 into primary heating chamber 280 and from primary heating chamber 280 to sprayers 120 through liquid outflow conduit 116 and/or liquid spray supply conduits 118, as described hereinabove with reference to Fig. 6.

Referring now to Fig. 9B, when a high temperature spray mode is actuated, the controller 150 is operative to turn heating element 206 on and to check if the temperature sensed by temperature sensor 350 is greater than a minimum threshold.
for high temperature spray, MIN $H$, typically 65°C.

If MIN $H$ has not been exceeded, the controller 150 is operative to check if an immediate spray mode has been actuated, such as by operator actuation or in response to a signal received from dirt sensor 128 or any other sensor. If an immediate spray mode has been actuated, the controller 150 is operative to actuate pump 108 in accordance with an immediate spray mode, such as the immediate spray mode described hereinabove with reference to Fig. 9A or any other suitable immediate spray mode. If an immediate spray mode has not been actuated, the controller 150 is operative to return and again check if the temperature sensed by temperature sensor 350 is greater than MIN $H$.

In the illustrated high temperature spray mode embodiment of Fig. 9B, when the temperature sensed by temperature sensor 350 exceeds MIN $H$, the controller 150 is operative to actuate pump 108 to provide a first spray. The first spray is preferably a short spray, provided for a first spray time period, $T_{H1}$, preferably 0.3-0.4 seconds. During the first spray, the controller 150 is operative, typically every 50 msec, to check if an immediate spray mode has been actuated, such as by operator actuation or in response to a signal received from dirt sensor 128 or any other sensor. If an immediate spray mode has been actuated, the controller 150 is operative to actuate pump in accordance with an immediate spray mode, such as the immediate spray mode described hereinabove with reference to Fig. 9A or any other suitable immediate spray mode. As long as immediate spray mode has not been actuated, the controller 150 is operative to actuate pump 108 to continue with the first spray of the high temperature mode, until $T_{H1}$ has been completed.

In the illustrated high temperature spray mode embodiment of Fig. 9B, upon the completion of the first spray, the controller 150 is operative to check if the temperature sensed by temperature sensor 350 is greater than a maximum temperature for high temperature spraying, MAX $H$, typically 68°C. If the temperature sensed by temperature sensor 350 exceeds MAX $H$, the controller 150 is operative to turn off heating element 206. The controller 150 is operative to check if the temperature sensed by temperature sensor 350 is less than MIN $H$. If the temperature sensed by temperature sensor 350 is less than MIN $H$, the controller 150 is operative to turn on heating element 206.
In the illustrated high temperature spray mode embodiment of Fig. 9B, the controller 150 is operative to check if an immediate spray mode has been actuated, such as by operator actuation or in response to a signal received from dirt sensor 128 or any other sensor. If an immediate spray mode has been actuated, the controller 150 is operative to actuate pump 108 in accordance with an immediate spray mode, such as the immediate spray mode described hereinabove with reference to Fig. 9A or any other suitable immediate spray mode.

If an immediate spray mode has not been actuated, the controller 150 is operative to begin a waiting period of duration THW, preferably about 7 seconds. During the waiting period, the controller 150 is operative periodically, typically every 50 msec, to check if the temperature sensed by temperature sensor 350 exceeds MAXH or is less than MINH or if an immediate spray mode has been actuated, such as by operator actuation or in response to a signal received from dirt sensor 128 or any other sensor, and to perform the appropriate functions as described above.

In the illustrated high temperature spray mode embodiment of Fig. 9B, at the conclusion of waiting period THW, the controller 150 is operative to provide a second spray. The second spray is preferably of a longer duration than the first spray, and is provided for a second spray time period, THS2, preferably about 1 second. During the second spray, the controller 150 is operative, typically every 50 msec, to check if an immediate spray mode has been actuated, such as by operator actuation or in response to a signal received from dirt sensor 128 or any other sensor. If an immediate spray mode has been actuated, the controller 150 is operative to actuate pump 108 in accordance with an immediate spray mode, such as the immediate spray mode described hereinabove with reference to Fig. 9A or any other suitable immediate spray mode. As long as an immediate spray mode has not been actuated, the controller 150 is operative to actuate pump 108 to continue with the second spray of the high temperature mode, until THS2 has been completed.

Upon completion of the second spray, the controller 150 is then operative to turn heating element 206 off.

It is appreciated, as described hereinabove, that the high temperature spray mode may be interrupted at any time by controller 150 upon receiving an immediate spray mode actuation, such as by operator actuation, or in response to a
signal received from dirt sensor 128 or any other sensor, and that controller 150 preferably does not return to the interrupted high temperature spray mode upon the completion of the immediate spray mode. It is also appreciated that whenever an immediate spray mode is actuated during the high temperature spray mode, upon completion of the immediate spray mode, controller 150 is operative to turn off heating element 206.

The system is operative to provide the first spray and the second spray of the high temperature spray mode by activating pump 108 to provide liquid through liquid inflow conduit 112 into secondary heating chamber 282 which causes liquid to flow from secondary heating chamber 282 into primary heating chamber 280 and from primary heating chamber 280 to sprayers 120 through liquid outflow conduit 116 and/or liquid spray supply conduits 118, as described hereinabove with reference to Fig. 6.

It is appreciated that the high temperature spray mode seen in the illustrated embodiment of Fig. 9B is for illustrative purposes only and that controller 150 may alternatively provide any other suitable high temperature spray mode.

It is appreciated that controller 150 and/or the vehicle computer may be operative to control heating element 206 and pump 108 in accordance with a high temperature spray mode in the event that dirt sensed by dirt sensor 128 exceeds a first threshold, and may be operative to control heating element 206 and pump 108 in accordance with an immediate spray mode in the event that dirt sensed exceeds a second threshold. It is further appreciated that, in the embodiment of the present invention shown in Fig. 1B, including multiple liquid heating units 110 connected to multiple pumps 108 and multiple dirt sensors 128, multiple dirt sensors 128 are preferably operative to send individual sensed dirt indications to controller 150, which is operative to actuate only the specific liquid heating unit 110 and/or pump 108 corresponding to the specific dirt sensor 128 where the sensed dirt indication exceeded the threshold. Alternatively, the controller 150 may be operative to activate multiple heating units 110 and/or multiple pumps 108 in response to a sensed dirt indication received from a single dirt sensor 128.

It is appreciated that liquid heating unit 110 is configured to retain the heat within liquid container 208 and specifically within the liquid contained therein. As described hereinabove, insulating material 400 and insulating material 404 encase liquid
container 208, including electrical contact portion 204 and heating element 206, within a first enclosure, and first thermal insulating cover assembly 200, second thermal insulating cover assembly 220 and insulating cover connection frame 216 encase liquid container 208 within a second enclosure, which preferably includes volumes 236 and 336 maintained under vacuum. The ability of the liquid heating unit 110 of the present invention to retain heat preferably provides the user with the availability of heated liquid without a long initial waiting period. It is appreciated that the heat retention capability of the present invention preferably allows for the provision of heated liquid even after an elapsed time during which the unit was turned off. Applicants have found that the liquid heating unit of the present invention provides heated liquid even after the system is turned off for a period of 2-5 hours.

It is appreciated that first spray times $T_{iS1}$ and $TH_{S1}$ for immediate spray mode and high temperature spray mode, respectively, may be of the same or of different durations. Also, second spray times $T_{iS2}$ and $TH_{S2}$ for immediate spray mode and high temperature spray mode, respectively, may be of the same or of different durations. It is further appreciated that waiting times $T_{iw}$ and $TH_{w}$, for immediate spray mode and high temperature spray mode, respectively, may be of the same or of different durations.

It is appreciated that minimum temperature $MIN_{H}$ and $MIN_{S}$, for high temperature spray mode and standby mode, respectively, may be the same or different than respective maximum temperatures $MAX_{H}$ and $MAX_{S}$, for high temperature spray mode and standby mode, respectively.

It is appreciated that the immediate spray mode and high temperature spray mode described hereinabove with reference to Figs. 9A and 9B are for illustration only and controller 150 may be operative to actuate pump 108 and heating element 206 in accordance with any suitable immediate or high temperature spray in response to immediate spray mode and high temperature spray mode actuations. It is also appreciated that controller 150 may be operative to provide a first immediate spray mode in response to user actuation and a second immediate spray mode in response to a system generated immediate spray mode actuation. Additionally, controller 150 may be operative to provide a first high temperature spray mode in response to user actuation and a second high temperature spray mode in response to a system generated high temperature spray mode actuation.
Reference is now made to Fig. 10, which is a simplified schematic illustration of a liquid collection and reuse system for use in a vehicle in accordance with a preferred embodiment of the present invention. As seen in Fig. 10, a liquid collection and reuse system 600 for use in a vehicle includes a liquid collection and filtration subsystem 610, a collection reservoir and pumping subsystem 620 and a vehicle liquid heating system 630 supplying liquid to vehicle sprayers 640.

Liquid collection and filtration subsystem 610 is operative to collect water and other liquids and to provide filtered collected liquid to collection reservoir and pumping subsystem 620. Liquid may be collected from drainage from a vehicle air conditioning unit 650 and/or an engine within a vehicle and/or one or more liquid collectors 652 associated with a vehicle. Liquid collectors 652 may be located inside the vehicle or exterior to the vehicle. Liquid collectors 652 are preferably operative to collect rainwater and other liquids. Collected liquid is preferably supplied, via a valve 654, to at least one filter 656. Filtered collected liquid is preferably collected in a collection reservoir 660.

Valve 654 is a two-position valve, which in a filter open position allows collected liquid to pass through to at least one filter 656 and in a filter closed position directs collected liquid to a drain 662. It is appreciated that valve 654 may be opened or closed manually by a vehicle operator or by an automatic signal from a system controller and/or by a user actuation signal. It is appreciated that valve 654 provides, in the filter closed position, for direct, pre-filtration, drainage of liquids that may not be suitable for the liquid collection and reuse system 600, such as when the vehicle passes through a car wash. It is appreciated that the system controller may receive a signal from an external source, such as from a car wash controller, to open and/or close valve 654.

The at least one filter 656 may include one or more conventional filters that generally allow liquids to pass therethrough and generally prevent solids from passing therethrough. It is appreciated that one or more filters 656 with different filtration properties may be included. Filters 656 may include any suitable disposable filters and/or reusable filters.

Collection reservoir and pumping subsystem 620 preferably includes at least one collection reservoir 660, a pump 670 driven by motor 674 and a one-way
valve 678, Collection reservoir 660 preferably includes an overflow drain 680, a liquid input aperture 682, preferably including a removable cover (not shown), a liquid level sensor 684 and a temperature sensor 688. One-way valve 678 allows liquid to flow from collection reservoir 660 to vehicle liquid heating system 630 and prevents liquid backflow from vehicle liquid heating system 630 into collection reservoir 660. Liquid input aperture 682 is provided to allow a user to add any suitable liquid to collection reservoir 660.

Vehicle liquid heating system 630 includes a reservoir 690 and a liquid heating system 694. Reservoir 690 may be a liquid reservoir associated with a vehicle liquid heating system, such as reservoir 106 of Figs. I A and IB, or may be an existing vehicle reservoir or any other reservoir placed in a vehicle. Reservoir 690 also preferably includes an overflow drain 696 and a liquid level sensor 698. Liquid heating system 694 may be any vehicle liquid heating system, such as system 102 of Figs. IA and IB, or any other conventional vehicle liquid heating system.

As seen on Fig. 10, valve 654, liquid level sensor 684, temperature sensor 688, motor 674 and liquid level sensor 698 are preferably in electrical communication with a liquid flow controller 700 via respective electrical connections 702, 704, 706, 708 and 710. Liquid flow controller 700 is preferably connected to a vehicle computer (not shown). Alternatively, the functionality of liquid flow controller 700 is included in the vehicle computer (not shown).

Liquid flow controller 700 is connected to a vehicle battery 720 via electrical cables 724. Liquid heating system 694 is also connected to battery 720 via cables 728. Additionally, liquid flow controller 700 may utilize an output signal from a conventional rain sensor (not shown) to actuate valve 654.

Alternatively, valve 654, liquid level sensor 684, temperature sensor 688, motor 674 and liquid level sensor 698 may be connected to any combination of device computers, such as liquid heating system 694 computer (not shown) or other vehicle located computers (not shown), preferably connected to the vehicle computer (not shown).

Collection reservoir and pumping subsystem 620 is operative upon receiving a liquid request signal from liquid flow controller 700 or other device, preferably in response to a low liquid level signal generated by liquid level sensor 698,
to actuate motor 674 and pump 670 to provide liquid from collection reservoir 660, via one-way valve 678, to reservoir 690. Collection reservoir and pumping subsystem 620 is preferably operative to check that liquid level in collection reservoir 660, as sensed by liquid level sensor 684, is appropriate to supply liquid to reservoir 690. Collection reservoir and pumping subsystem 620 is also preferably operative to check that the temperature in collection reservoir 660, as sensed by temperature sensor 688, is higher than a threshold temperature, typically 5°C, to ensure that liquid in collection reservoir 660 is not frozen.

It is appreciated that, although in the illustrated embodiment collection reservoir and pumping subsystem 620 supplies liquid to vehicle liquid heating system 630, collection reservoir and pumping subsystem 620 may be operative to provide a supply of liquid for any suitable vehicle use, such as to supply liquid to the vehicle engine cooling system or to supply liquid for a vehicle operator to wash his hands with.

Reference is now made to Fig. 11, which is a simplified schematic illustration of a liquid collection and reuse system for use in a vehicle in accordance with another preferred embodiment of the present invention. As seen in Fig. 11, a liquid collection and reuse system 800 for use in a vehicle includes a liquid collection and filtration subsystem 810, a collection reservoir and pumping subsystem 820 and a vehicle liquid heating system 830 supplying liquid to vehicle sprayers 840.

Liquid collection and filtration subsystem 810 is preferably identical to liquid collection and filtration subsystem 610 of Fig. 10 and vehicle liquid heating system 830 is preferably identical to vehicle liquid heating system 630 of Fig. 10.

Collection reservoir and pumping subsystem 820 is similar to collection reservoir and pumping subsystem 620 and includes a collection reservoir 860, at least one additional reservoir 864, (two additional reservoirs 864 are shown in the illustrated embodiment) multiple pumps 870, preferably volumetric pumps, driven by motor 874 and multiple one-way valves 876 and 877. Additional reservoirs 864 each preferably include a liquid level sensor 878 and a liquid input aperture 882, preferably including a removable cover (not shown). Additional reservoirs 864 may also include a temperature sensor (not shown).

Collection reservoir 860 is preferably identical to collection reservoir 660 and preferably includes overflow drain 680, liquid input aperture 682, liquid level sensor 684, and a check valve 686. A collection reservoir 860 also includes a liquid input aperture 882 and an overflow drain 876.
sensor 684 and temperature sensor 688. One-way valves 876 and 877 allow liquid to flow from collection reservoir 860 and additional reservoirs 864 to vehicle liquid heating system 830 and prevent liquid backflow from vehicle liquid heating system 830 into collection reservoir 860 and additional reservoirs 864. Additionally, one-way valves 877 prevent liquid from collection reservoir 860 from flowing into additional reservoirs 864. Liquid input apertures 882 are provided to allow a user to add any suitable liquid to additional reservoirs 864.

Collection reservoir and pumping subsystem 820 also preferably includes at least one two-position valve 890 (two additional two-position valves 890 are shown in the illustrated embodiment), each associated with one of the at least one additional reservoirs 864. Valves 890 are operative in a first position to allow liquid from additional reservoirs 864 to flow, via pump 870, to vehicle liquid heating subsystem 830 and in a second position to return liquid to the additional reservoir 864 from where the liquid was pumped. It is appreciated that valves 890 may be operated in response to an automatic signal from a system controller or a user actuation signal.

As seen on Fig. 11, valve 654, liquid level sensors 878 and 684, temperature sensor 688, motor 874, liquid level sensor 698 and two-position valves 890 are preferably in electrical communication with a liquid flow controller 900 via respective electrical connections 902, 904, 906, 908, 910, 912 and 914. Liquid flow controller 900 is preferably connected to a vehicle computer (not shown). Alternatively, the functionality of liquid flow controller 900 is included in the vehicle computer (not shown).

Liquid flow controller 900 is connected to a vehicle battery 920 via electrical cables 924. Liquid heating system 694 is also connected to battery 920 via cables 928. Preferably, liquid flow controller 900 is also connected to at least one temperature sensor 930 located inside the vehicle or outside the vehicle to measure ambient temperature. Additionally, liquid flow controller 900 may utilize an output signal from a conventional rain sensor (not shown) to actuate valve 654.

Alternatively, valve 654, liquid level sensors 878 and 684, temperature sensor 688, motor 874, liquid level sensor 698 and two-position valves 890 may be connected to any combination of device computers, such as liquid heating system 694 computer (not shown) or other vehicle located computers (not shown), preferably
connected to the vehicle computer (not shown).

Collection reservoir and pumping subsystem 820 is operative, upon receiving a liquid request signal from liquid flow controller 900 or other device, preferably in response to a low liquid level signal generated by liquid level sensor 698, to actuate motor 874 and pumps 870 to provide liquid from collection reservoir 860 and/or from one or more additional reservoirs 864, via two-way valves 890 and one-way valves 876 and 877, to reservoir 690.

A preferred embodiment of the operation of the collection reservoir and pumping system of Fig. 11 is now described. Collection reservoir and pumping subsystem 820 is preferably operative to check that the liquid level in collection reservoir 860, as sensed by liquid level sensor 684, is appropriate to supply liquid. Collection reservoir and pumping subsystem 820 is also preferably operative to check that the temperature in collection reservoir 860, as sensed by temperature sensor 688, is higher than a threshold temperature, typically 5°C, to ensure that the liquid in collection reservoir 860 is not frozen.

Additionally, collection reservoir and pumping subsystem 820 is preferably operative to check that liquid level in one or more additional reservoirs 864, as sensed by liquid level sensors 878, is appropriate to supply liquid. Collection reservoir and pumping subsystem 820 is also preferably operative to check that the temperature in one or more additional reservoir 864, as sensed by temperature sensors therein (not shown), is higher than a threshold temperature, typically 5°C, to ensure that liquid in additional reservoirs 864 is not frozen.

Collection reservoir and pumping subsystem 820 is then preferably operative to actuate motor 874 to operate one or more of pumps 870 to pump liquid from at least one of collection reservoir 860 and additional reservoirs 864, via one-way valves 876 and 877 to reservoir 690. A preferred embodiment of the present invention, motor 874 is operative to operate all of pumps 870, and collection reservoir and pumping subsystem 820 controls flow to reservoir 690 through the positioning of two-way valves 890. Alternatively, motor 874 may be operative to operate only a subset of pumps 870 to provide liquid to reservoir 690 and two-way valves 890 may be obviated. In another alternative embodiment of the present invention, each of pumps 870 may be connected to a respective motor.
It is appreciated that the provision of two-way valves 890 allows a mixture of liquids from collection reservoir 860 and additional reservoirs 864 to be provided to reservoir 690. It is appreciated that collection reservoir 860 and additional reservoirs 864 may contain different liquids or the same liquid.

Liquid flow controller 900 is preferably operative to control collection reservoir and pumping subsystem 820 to provide the appropriate mixing of liquids from collection reservoir 860 and additional reservoirs 864.

An example of the functionality provided by system of Fig. 11 is now provided. Collection reservoir 860 is preferably filled with water, while additional reservoirs 864 preferably contain liquid anti-freeze. Based on the temperature sensed by sensor 930, liquid flow controller 900 is operative to provide an optimal mix of water and anti-freeze to reservoir 690 by operating pumps 870 and two-way valves 890 as appropriate.

It is appreciated that, although in the illustrated embodiment collection reservoir and pumping subsystem 820 supplies liquid to vehicle liquid heating system 830, collection reservoir and pumping subsystem 820 may be operative to provide a supply of liquid for any suitable vehicle use, such as to supply liquid to the vehicle engine cooling system or to supply liquid for a vehicle operator to wash his hands with.

Reference is now made to Fig. 12, which is a simplified pictorial illustration of a vehicle windshield cleaning and de-icing system, constructed and operative in accordance with another preferred embodiment of the present invention, installed in a motor vehicle.

As seen in Fig. 12, an otherwise conventional motor vehicle 1100 is seen to incorporate a windshield cleaning and de-icing system 1120 for cleaning and/or de-icing a vehicle windshield 1124. The windshield cleaning and de-icing system 1120 preferably includes a vessel 1128, for heating liquid received from a reservoir 1130, which provides heated liquid, such as water or windshield cleaning liquid, to spray heads 1132 for spraying onto windshield 1124. Vessel 1128 has an inlet 1134, which receives liquid from reservoir 1130, and an outlet 1136 through which heated liquid is discharged to spray heads 1132. The liquid is driven by a pump 1140, which is generally already present in automobile 1100 for spraying unheated liquid to clean windshield 1124.
A battery 1142 provides power to windshield cleaning and de-icing system 1120, and wipers 1144 clean melted ice and dirt from the windshield, as is known in the art. A controller 1146 regulates the operation of windshield cleaning and de-icing system 1120, and optionally also controls wipers 1144 in conjunction with operation of windshield cleaning and de-icing system 1120.

One or more temperature sensors, in communication with controller 1146, are preferably provided to measure the temperature of the liquid in vessel 1128 and may also measure the temperature of the spray heads 1132. Additionally, one or more temperature sensors, preferably in communication with controller 1146, may be provided to measure the temperature external to vessel 1128, such as a windshield temperature sensor 1148, a vehicle exterior temperature sensor 1150 and a vehicle interior temperature sensor 1152. It is appreciated that sensor 1148 is preferably placed along the surface of the windshield 1124 in a similar fashion to the windshield temperature sensor described in reference to Fig. 3 of applicant's U.S. Patent 6,615,438 and may similarly include a reflective cover.

It is appreciated that spray heads 1132, which are located on a wiper arm in the illustrated embodiment, may be located in any other suitable location, such as adjacent windshield 1124 or on wipers 1144.

Additional sensors may also be provided, such as a wind speed sensor or a dirt sensor. Controller 1146 may also be operative to receive additional inputs concerning vehicle operational parameters and/or external conditions from a vehicle computer and/or from existing vehicle sensors, as described further hereinbelow.

It is appreciated that vessel 1128 may include any suitable vessel, such as the vessel described in Figs. 2 - 6B hereinabove or those described in applicants' assignee's U.S. Patent Nos. 6,164,564; 6,615,438; 6,669,105; 6,892,417 and 7,108,754 applicants' assignee's U.S. Patent Application Nos. 11/203,779; 10/700,141; 10/477,486 and 10/531,979 and applicants' assignee's PCT Application Serial No. PCT/IL2005/00179, the disclosures of which are hereby incorporated by reference.

Reference is now made to Fig. 13, which is a simplified sectional illustration of a vessel for heating liquid which may form part of the vehicle windshield cleaning and de-icing system of Fig. 12. It is appreciated that the embodiment of Fig. 13 is for illustrative purposes only and the vehicle windshield cleaning and de-icing system
of Fig. 12 may also utilize any other suitable vessel for heating liquid, including but not limited to the vessel shown hereinbelow in Fig. 16.

Turning to Fig. 13, it is seen that vessel 1128 includes a housing portion 1300, preferably formed of a plastic material, which defines a liquid heating area 1302. At least one heating element 1322 is disposed within liquid heating area 1302. Liquid to be heated is typically received into liquid heating area 1302 of vessel 1128 via an inlet 1326. Heated liquid typically exits at the top of the liquid heating area 1302 via a conduit 1330, also typically defined by housing portion 1300, to an outlet 1334. Outlet 1334 is in fluid communication with spray heads 1132 (Fig. 12).

It is appreciated that even though the illustrated embodiment of Fig. 13 shows vessel 1128 including two heating elements 1322, vessel 1128 may include a single heating element 1322, or more than two heating elements 1322, to heat the liquid within liquid heating area 1302.

A liquid temperature sensor 1340 preferably is located near the top of the liquid heating area 1302 adjacent an inlet to conduit 1330. Another temperature sensor 1342 is preferably located in a wall 1344 of the liquid heating chamber 1302. Temperature sensors 1340 and 1342 provide electrical outputs to a controller 1350, typically located within housing 1300. Controller 1350 controls the electrical power to heating elements 1322. It is appreciated that in the event that more than one heating element 1322 is provided, each of the heating elements 1322 are preferably controlled individually by controller 1350, and may be operated at various power levels, as described further hereinbelow.

As described hereinabove, controller 1350 may be included in housing 1300 or the functionality of controller 1350 may be included in a vehicle computer or computers (not shown) or any combination thereof. Controller 1350 is preferably in communication with one or more sensors, as described hereinabove.

It is appreciated that controller 1350 may utilize information provided by either temperature sensor 1340 or temperature sensor 1342, or a combination of information from both sensors 1340 and 1342, to control the operation of heating elements 1322, as described further hereinbelow.

Vessel 1128 may also include a circulation pump 1362 for circulating heated liquid through conduits 1364 and 1366 to heat external components of the
system such as liquid sprayers and windshield wiper blades, as well as to heat heated
liquid supply conduits, such as a conduit 1368 coupled to outlet 1334.

Circulation pump 1362 may be operated by electronic heating control

circuitry 1350 automatically on the basis of any suitable criteria.

Reference is now made to Fig. 14, which is a simplified flow chart of a

method to ascertain a 'near-boiling temperature' of a liquid.

As seen in Fig. 14, controller 1350 is operative to turn on at least one of

heating elements 1322, preferably to a maximum heating level. Controller 1350 also

obtains and saves a value of a first temperature measurement of the liquid in vessel

1128, Tempi, which is typically received from one of sensors 1340 and 1342, or may be

a function of information received from both sensors 1340 and 1342 or any other sensor

or sensors operative to provide information pertaining to the temperature of the liquid in

vessel 1128.

If Tempi is equal to or greater than a predetermined minimum, such as

30°C, controller 1350 is operative to continue to heat the liquid in vessel 1128 for a

predetermined interval, typically 6 seconds, and to obtain and save a second temperature

measurement of the liquid in vessel 1128, Temp₂. Controller 1350 calculates the

temperature difference as (Temp₂-Tempi).

If the temperature difference is less than a predetermined minimum

change, typically 2°C, controller 1350 is operative to set the 'near-boiling temperature'

of the liquid to a predetermined value, typically 60°C. Preferably, controller 1350 is

operative to ascertain a new 'near-boiling temperature' after a predetermined time

interval, typically 30 minutes, if the vehicle has not been turned off in the interim. If the

vehicle has been turned off during the predetermined time interval, the controller 1350

is operative at vehicle start up to ascertain a new 'near-boiling temperature'.

If the temperature difference is greater than or equal to the predetermined minimum

change, the value of Temp₁ is updated to be the value Temp₂ and the process

continues as described further hereinbelow.

If Tempi is less than a predetermined minimum, such as 30°C, controller

1350 is operative to continue to heat the liquid in vessel 1128 and to obtain and save a

new value for Temp₁, until Tempi is equal to or exceeds the predetermined minimum.

Controller 1350 then waits for a predetermined time, typically 1-2
seconds, and then obtains and saves a value of a second temperature measurement of the liquid in vessel 1128, $\text{Temp}_2$. $\text{Temp}_2$ and $\text{Temp}_1$ are compared to see if the difference is less than a predetermined stability value, typically 0.1°C. If the difference is greater than or equal to the predetermined stability value, the value of $\text{Temp}_1$ is updated to be the value $\text{Temp}_2$ and the process is repeated.

If the difference is less than the predetermined stability value, the controller 1350 sets the 'near-boiling temperature' of the liquid to the value $\text{Temp}_2$. The controller 1350 then preferably turns off the at least one of heating elements 1322 and the near-boiling temperature ascertaining process ends. Alternatively, the controller 1350 may leave the at least one of heating elements 1322 on and end the near-boiling temperature ascertaining process.

It is appreciated that controller 1350 is typically operative to ascertain the 'near-boiling temperature' of the liquid at vehicle start up and to store that value for use in setting standby temperature thresholds, as described hereinbelow. It is appreciated that controller 1350 may be operative to retrieve a stored 'near-boiling temperature' from a previous vehicle start up in the event that the vehicle was turned off for a period of time less than a predetermined duration, such as 10 minutes, and/or based on information received from a vehicle reservoir sensor (not shown) relating to a liquid level in the reservoir.

In a further embodiment of the present invention, controller 1350 may be operative to re-ascertain the 'near-boiling temperature' of the liquid in response to information received from a vehicle reservoir sensor (not shown) relating to a liquid level in the reservoir 1130. In this embodiment, controller 1350 may be operative to wait until the liquid in the vessel 1128 has been replaced with liquid from the reservoir 1130, for example, until one or two spray cycles have been performed, before ascertaining a new 'near-boiling temperature.' It is appreciated that in this embodiment the vehicle reservoir sensor is operative to provide an indication of a significant change in the liquid level in the reservoir 1130 to controller 1350, for example, if the level of liquid in the reservoir 1130 increases by a predetermined percentage, such as 20%.

It is appreciated that controller 1350 may interrupt the near-boiling ascertaining process described hereinabove if an immediate spray actuation is received. The immediate spray actuation may be generated by controller 1350, such as in
response to a signal received from a dirt sensor or any other sensor, or received from an actuation device, such as an operator actuation device. In the event of an immediate spray actuation being received by controller 1350, controller 1350 turns off heating elements 1322, actuates pump 1140 in accordance with an immediate spray mode, and then begins the near-boiling ascertaining process again upon completion of the immediate spray mode.

In accordance with a preferred embodiment of the present invention, controller 1350 is operative to utilize the 'near-boiling temperature' to set at least one pair of standby thresholds. Controller 1350 may also receive inputs from at least one sensor for use in setting at least one pair of standby thresholds. As described hereinabove, controller 1350 is operative to set a pair of standby thresholds for each sensor in a 'primary temperature sensor' for each operational mode of system 1120.

In one embodiment of the present invention, controller 1350 may be operative to set a pair of standby thresholds for controlling the operation of heating elements 1322 during standby mode based only on the value of the 'near-boiling temperature'. In this embodiment, controller 1350 sets an upper standby threshold to be equal to a first predetermined value, such as 15°C, less than the 'near-boiling temperature', and sets a lower standby threshold to be equal to a second predetermined value, lower than the first predetermined value, such as 20°C, less than the 'near-boiling temperature'.

In another embodiment of the present invention, controller 1350 may be operative to set a pair of standby thresholds for controlling the operation of heating elements 1322 during standby mode based on the value of the 'near-boiling temperature' and additional information. In this embodiment, controller 1350 may set upper and lower standby thresholds based on different mathematical functions using the value of the 'near-boiling temperature' and at least one additional value, such as a temperature of the vehicle exterior, vehicle interior or the liquid in reservoir 1130.

In one example of this embodiment, controller 1350 may be operative to set a pair of standby thresholds for controlling the operation of heating elements 1322 during standby mode based on the value of the 'near-boiling temperature' and the temperature of the liquid in reservoir 1130. In this embodiment, controller 1350 sets the upper standby threshold and the lower standby threshold based on a lookup table which
is a function of the 'near boiling temperature' and the temperature of the liquid in reservoir 1130. For example, if the 'near boiling temperature' is between 65°C and 75°C then the values for the lookup table may be as follows:

<table>
<thead>
<tr>
<th>Temperature of liquid in Reservoir 1130</th>
<th>Upper Standby Threshold</th>
<th>Lower Standby Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;30°C</td>
<td>35°C</td>
<td>30°C</td>
</tr>
<tr>
<td>5°C -30°C</td>
<td>40°C</td>
<td>35°C</td>
</tr>
<tr>
<td>&lt;5°C</td>
<td>45°C</td>
<td>40°C</td>
</tr>
</tbody>
</table>

It is appreciated that the difference between the upper standby threshold and the lower standby threshold may be predetermined or may be a function of the determinants of the thresholds.

In a further preferred embodiment of the present invention, where system 1120 also includes a circulation pump, such as circulation pump 1362 of the embodiment of Fig. 13, controller 1350 may be operative to increase and/or decrease the upper standby threshold and/or lower standby threshold upward by a predetermined amount, such as 5°C, if the circulation pump is in operation.

It is appreciated that in embodiments of the present invention including setting standby thresholds based on additional information, the controller 1350 may be operative to set new standby thresholds after a predetermined interval, typically 10 minutes.

It is appreciated that the ascertaining of the 'near-boiling temperature' and the setting of the standby thresholds based thereon, as described hereinabove, enables heating of the liquid to an appropriate standby level, which allows for heated liquid to be provided rapidly for heated spraying and also minimizes evaporation of the liquid.

Reference is now made to Fig. 15, which is a simplified flow chart of a preferred mode of operation of the system of Figs. 12 - 13.

As seen in Fig. 15, controller 1350 is operative to periodically check if the vehicle ignition has been turned on, typically every 50 msec. Once controller 1350 detects that the vehicle ignition is turned on, it then periodically, typically every 50 msec, checks if the engine voltage is greater than a minimum voltage, MINy, typically 12v. Controller 1350 may also be operative to ensure that other vehicle parameters are within predetermined ranges.
When the controller 1350 detects that the ignition is on and that the minimum voltage threshold has been met, the controller 1350 is operative to ascertain a 'near-boiling temperature' and to set at least one pair of standby thresholds, as described hereinabove with reference to Fig. 14. It is appreciated that controller 1350 may ascertain a 'near-boiling temperature' by retrieving a stored 'near-boiling temperature' from a previous vehicle start up in the event that the vehicle was turned off for a period of time less than a predetermined duration, as described hereinabove with reference to Fig. 14, and may utilize the retrieved 'near-boiling temperature' to set at least one pair of standby thresholds.

As described hereinabove with reference to Fig. 14, it is appreciated that controller 1350 may interrupt the near-boiling ascertaining process upon receiving an immediate spray actuation. In the event of an immediate spray actuation being received by the controller 1350, the controller 1350 turns off heating elements 1322, actuates pump 1140 in accordance with an immediate spray mode, such as the immediate spray mode described hereinabove with reference to Fig. 9A or any other suitable immediate spray mode, and then begins the near-boiling ascertaining process again.

Upon completion of the near-boiling ascertaining process, the controller 1350 is operative to control the operation of heating elements 1322 in accordance with a standby mode based on the at least one pair of standby thresholds and information received from the 'primary temperature sensor.' As seen in Fig. 15, the standby mode preferably provides a recurring cycle of operations until the vehicle ignition is turned off.

It is appreciated that in the embodiment shown in Fig. 13, the primary temperature sensor may be either of sensors 1340 or 1342, or any other sensor providing information pertaining to the temperature of the liquid in vessel 1128.

In accordance with the embodiment of Fig. 15, controller 1350 is operative, when operating in standby mode, to check if an immediate spray mode has been actuated, such as by operator actuation or an automatically generated immediate spray actuation. If an immediate spray mode has been actuated, controller 1350 is operative to actuate pump 1140 in accordance with an immediate spray mode. If the immediate spray mode is actuated by an operator, controller 1350 may actuate pump 1140 to provide an immediate spray of liquid onto the windshield for the duration of the
operator actuation or any other suitable duration.

If the immediate spray actuation is an automatically generated immediate spray actuation, controller 1350 may be operative to actuate pump 1140 in accordance with an immediate spray mode, such as the immediate spray mode described hereinabove with reference to Fig. 9A, or any other suitable immediate spray mode.

If an immediate spray mode has not been actuated, controller 1350 is operative to check if a high temperature spray mode has been actuated, such as by operator actuation or an automatically generated high temperature spray actuation. If a high temperature spray mode has been actuated, controller 1350 is operative to control pump 1140 and heating elements 1322 in accordance with a high temperature spray mode.

If the high temperature spray mode is actuated by an operator, controller 1350 is operative to control pump 1140 and heating elements 1322 in accordance with a high temperature spray mode, such as the high temperature spray mode described hereinabove with reference to Fig. 9B or any other suitable high temperature spray mode, such as the automatic or high temperature spraying modes described in applicants/assignee's U.S. Patent Nos. 6,164,564; 6,615,438; 6,669,105; 6,892,417 and 7,108,754, applicants/assignee's U.S. Patent Application Nos. 11/203,779; 10/700,141; 10/477,486 and 10/531,979, and applicants/assignee's PCT Application Serial No. PCT/IL2005/00179, the disclosures of which are hereby incorporated by reference.

If the high temperature spray actuation is an automatically generated high temperature spray actuation, controller 1350 is operative to control pump 1140 and heating elements 1322 in accordance with a high temperature spray mode, such as the high temperature spray mode described hereinabove with reference to Fig. 9B or any other suitable high temperature spray mode, such as the automatic or high temperature spraying modes described in applicants/assignee's U.S. Patent Nos. 6,164,564; 6,615,438; 6,669,105; 6,892,417 and 7,108,754, applicants/assignee's U.S. Patent Application Nos. 11/203,779; 10/700,141; 10/477,486 and 10/531,979 and applicants/assignee's PCT Application Serial No. PCT/IL2005/00179, the disclosures of which are hereby incorporated by reference.

If high temperature spray mode has not been actuated, controller 1350 then receives an input from the primary temperature sensor and compares it to the
respective upper standby threshold and lower standby threshold.

If the temperature sensed by the temperature sensor is greater than the upper standby threshold, controller 1350 is operative to turn off heating elements 1322.

If the temperature sensed by the temperature sensor is less than or equal to the upper standby threshold and greater than or equal to the lower standby threshold, controller 1350 may be operative to control heating elements 1322 in accordance with a maintain temperature operating mode. In one embodiment of the maintain temperature operating mode, controller 1350 may be operative to operate one or more heating elements 1322 at predetermined power levels. In another embodiment of the maintain temperature operating mode, controller 1350 may be operative to turn off heating elements 1322.

It is appreciated that the number of heating elements and the predetermined power level for each may be provided by a lookup table, or any suitable control method, based on the value of the temperature sensed relative to the upper standby threshold and the lower standby threshold. Thus, for example, controller 1350 may provide a lower percentage of the maximum power, such as 35%, if the difference between the temperature sensed and the upper standby threshold is less than the difference between the temperature sensed and the lower standby threshold, and may provide a higher percentage of the maximum power, such as 70%, if the temperature difference between the temperature sensed and the upper standby threshold is greater than the difference between the temperature sensed and the lower standby threshold.

It is appreciated that the selection of the embodiment to be employed by controller 1350 in the maintain temperature operating mode may be predetermined based on vehicle specifications, or may be a function of one or more sensors providing real-time information relating to the vehicle operating environment, such as engine power level, temperature within the engine compartment, or any other suitable parameter.

If the temperature sensed by the temperature sensor is less than the lower standby threshold, controller 1350 is operative to control heating elements 1322 in accordance with an increase temperature operating mode. In one embodiment of the increase temperature operating mode, controller 1350 may be operative to operate one or more heating elements 1322 at a predetermined power level. Alternatively, controller
1350 may be operative to operate one or more heating elements 1322 at maximum power when the temperature sensed is less than the lower standby threshold. In another alternative embodiment, controller 1350 may be operative to control the number of heating elements to operate and the power level for their operation by accessing a lookup table based on the difference between the temperature sensed and the lower standby threshold.

Thus, for example, controller 1350 may operate all of heating elements 1322 at maximum power if the difference between the temperature sensed and the lower standby threshold is greater than 100°C and may operate only a single heating element 1322 at maximum power if the difference between the temperature sensed and the lower standby threshold is less than 50°C. Alternatively, controller 1350 may operate more than one heating element 1322 at less than maximum power if the difference between the temperature sensed and the lower standby threshold is less than 50°C.

It is appreciated that the selection of the embodiment to be employed by controller 1350 in the increase temperature operating mode may be predetermined based on vehicle specifications, or may be a function of one or more sensors providing real-time information relating to the vehicle operating environment, such as engine power level, temperature within the engine compartment, or any other suitable parameter.

It is appreciated that controller 1350 may be operative to save the operating parameters associated with each of heating elements 1322 from each cycle of the standby mode and to compare the operating parameters from the previous cycle of the standby mode with the operating parameters of the present cycle to minimize the numbers of commands required to control heating elements 1322.

It is appreciated that controller 150, described hereinabove with reference to Figs. 1 - 5B, may also be operative according to the functionality described hereinabove with reference to Figs. 14 and 15.

Thus, controller 150 may be operative to ascertain a near-boiling temperature of the fluid in liquid container 208, as described hereinabove in reference to Fig. 14, preferably using temperature sensor 350. Controller 150 may also be operative to provide an operational cycle, including a standby mode, as described hereinabove with reference to Fig. 15.

In a preferred embodiment of the present invention, controller 150 is
operative to set an upper and lower standby threshold for the temperature of the liquid in primary heating chamber 280 and an upper and lower standby threshold for the temperature of the liquid in secondary heating chamber 282 based on the near-boiling temperature of the fluid in liquid container 208, as described hereinabove with reference to Fig. 15. In this embodiment, controller 150 may be operative to select one of sensors 350 or 352 to be the primary temperature sensor, as described further hereinbelow.

In this embodiment, controller 150 is preferably operative to initially select first temperature sensor 350 to be the primary temperature sensor and to control heating element 206 based on the upper and lower standby threshold set for the liquid in primary heating chamber 280 and the temperature sensed by sensor 350.

Thus, as described hereinabove with reference to Fig. 15, if the temperature sensed by first temperature sensor 350 is greater than the upper standby threshold set for the liquid in primary heating chamber 280, controller 150 turns off heating element 206. If the temperature sensed by first temperature sensor 350 is less than the lower standby threshold set for the liquid in primary heating chamber 280, controller 150 is operative to control heating element 206 in accordance with an increase temperature operating mode. In one embodiment of the increase temperature operating mode, controller 150 may be operative to operate heating element 206 at a predetermined power level. Alternatively, controller 150 may be operative, in an increase temperature operating mode, to operate heating element 206 at maximum power. In another alternative embodiment of an increase temperature operating mode, controller 150 may be operative to control the power level for operation of heating element 206 by accessing a lookup table based on the difference between the temperature sensed by first temperature sensor 350 and the lower standby threshold set for the liquid in primary heating chamber 280.

As described hereinabove with reference to Fig. 15, if the temperature sensed by first temperature sensor 350 is less than or equal to the upper standby threshold set for the liquid in primary heating chamber 280 and greater than or equal to the lower standby threshold set for the liquid in primary heating chamber 280, controller 150 is operative to control heating element 206 in accordance with a maintain temperature operating mode. In accordance with a preferred embodiment of the present invention, in the maintain temperature operating mode, controller 150 may be operative
to select second temperature sensor 352 to be the primary temperature sensor and to operate heating element 206 based on the upper and lower standby thresholds set for the liquid in secondary heating chamber 282 and the temperature sensed by sensor 352.

Thus, if the temperature sensed by second temperature sensor 352 is greater than the upper standby threshold set for the liquid in secondary heating chamber 282, controller 150 may be operative to turn off heating element 206. Alternatively, controller 150 may be operative to turn off heating element 206 if the temperature sensed by second temperature sensor 352 is greater than the lower standby threshold set for the liquid in secondary heating chamber 282.

If the temperature sensed by second temperature sensor 352 is less than the lower standby threshold set for the liquid in secondary heating chamber 282, controller 150 may be operative to operate heating element 206 at a predetermined power level. In another alternative embodiment, controller 150 may be operative to control the power level for the operation of heating element 206, by accessing a lookup table, based on the difference between the temperature sensed by second temperature sensor 352 and the lower standby threshold set for the liquid in secondary heating chamber 282.

Alternatively, controller 150 may be operative to set an upper and lower standby threshold only for the temperature of the liquid in primary heating chamber 280 and may be operative to provide standby functionality similar to the standby functionality of controller 1350 described hereinabove. In this embodiment, controller 150 may be operative to control the operation of heating element 206 based on the temperature sensed by first temperature sensor 350.

Reference is now made to Fig. 16, which is a simplified exploded view illustration of a vessel for heating liquid which may form part of the vehicle windshield cleaning and de-icing system of Fig. 12, in accordance with another preferred embodiment of the present invention.

As seen in Fig. 16, a vessel 1400 preferably includes a first conduit element 1410 and a second conduit element 1412 defining, respectively, a primary liquid heating volume portion and a secondary liquid heating volume portion. Preferably, mounted onto vessel 1400 there is provided a controller 1414, typically
including an electrical circuit board 1416, and a plurality of heating elements 1418 in
electrical communication with circuit board 1416.

A first liquid temperature sensor 1426, which senses the temperature of
liquid as it leaves vessel 1400, is also preferably coupled to circuit board 1416. A
second liquid temperature sensor 1428, which senses the temperature of liquid in
secondary liquid heating volume portion, is also in electrical communication with
circuit board 1416.

Controller 1414 provides, inter alia, control of the operation of liquid
heating elements 1418 via electrical circuitry on electrical circuit board 1416.

First conduit element 1410 is preferably formed of a heat conductive
material, such as aluminum, and is in direct heat exchange relationship with heating
elements 1418. Second conduit element 1412 is preferably formed of a somewhat
flexible and resilient material, such as LEXAN®, and is preferably sealingly attached to
first conduit element 1410 and to a heat conductive displaceable element, preferably an
intervening liquid impermeable diaphragm 1450. The diaphragm 1450 may be formed
as a separate element, as shown in Fig. 16, or alternatively may be integrally formed
with second conduit element 1412.

Fig. 16 illustrates a typical liquid flow defined by first and second
conduit elements 1410 and 1412, extending from a liquid ingress opening 1452 in
second conduit element 1412, via a conduit 1454 defined therein and via one or more
apertures 1456 formed in diaphragm 1450, through a conduit 1458 formed in first
conduit element 1410 and out through a heated liquid egress opening 1460 formed in
the first conduit element 1410.

Controller 1414 is operative to provide functionality similar to the
functionality of controller 1350 described hereinabove with reference to Figs. 14 and
15. Thus, controller 1414 is operative to ascertain a near-boiling temperature of the fluid
in vessel 1400, as described hereinabove in reference to Fig. 14, preferably using
temperature sensor 1426. Preferably, controller 1414 is also operative to provide an
operational cycle, including a standby mode, as described hereinabove with reference to
Fig. 15.

In a preferred embodiment of the present invention, controller 1414 is
operative to set an upper and lower standby threshold for the temperature of the liquid
in first conduit element 1410 and an upper and lower standby threshold for the
temperature of the liquid in second conduit element 1412 based on the near-boiling
temperature of the fluid in vessel 1400, as described hereinabove with reference to Fig. 14. In this embodiment, controller 1414 may be operative to select which one of sensors 1426 or 1428 is to be the primary temperature sensor, as described further hereinbelow.

In this embodiment, controller 1414 is preferably operative to initially select sensor 1426 to be the primary temperature sensor and to utilize the upper and lower standby threshold set for the liquid in first conduit element 1410 to control heating elements 1418.

Thus, as described hereinabove with reference to Fig. 15, if the temperature sensed by temperature sensor 1426 is greater than the upper standby threshold set for the liquid in first conduit element 1410, controller 1414 turns off heating elements 1418. If the temperature sensed by temperature sensor 1426 is less than the lower standby threshold set for the liquid in first conduit element 1410, controller 1414 is operative to control heating elements 1418 in accordance with an increase temperature operating mode. In one embodiment of the increase temperature operating mode, controller 1414 may be operative to operate one or more heating elements 1418 at a predetermined power level. Alternatively, controller 1414 may be operative, in an increase temperature operating mode, to operate one or more heating elements 1418 at maximum power. In another alternative embodiment of an increase temperature operating mode, controller 1414 may be operative to control the number of heating elements to operate and the power level for their operation, by accessing a lookup table, based on the difference between the temperature sensed by temperature sensor 1426 and the lower standby threshold set for the liquid in first conduit element 1410.

As described hereinabove with reference to Fig. 15, if the temperature sensed by temperature sensor 1426 is less than or equal to the upper standby threshold set for the liquid in first conduit element 1410 and greater than or equal to the lower standby threshold set for the liquid in first conduit element 1410, controller 1414 is operative to control heating elements 1418 in accordance with a maintain temperature operating mode. In accordance with a preferred embodiment of the present invention, in the maintain temperature operating mode, controller 1414 may be operative to select
temperature sensor 1428 to be the primary temperature sensor and to operate one or more heating elements 1418 based on the upper and lower standby thresholds set for the liquid in second conduit element 1412.

Thus, if the temperature sensed by temperature sensor 1428 is greater than the upper standby threshold set for the liquid in second conduit element 1412, controller 1414 may be operative to turn off heating elements 1418. Alternatively, controller 1414 may be operative to turn off heating elements 1418 if the temperature sensed by temperature sensor 1428 is greater than the lower standby threshold set for the liquid in second conduit element 1412.

If the temperature sensed by temperature sensor 1428 is less than the lower standby threshold set for the liquid in second conduit element 1410, controller 1414 may be operative to operate one or more heating elements 1418 at a predetermined power level. In another alternative embodiment, controller 1414 may be operative to control the number of heating elements to operate and the power level for their operation, by accessing a lookup table, based on the difference between the temperature sensed by temperature sensor 1428 and the lower standby threshold set for the liquid in second conduit element 1412.

Alternatively, controller 1414 may be operative to set an upper and lower standby threshold only for the temperature of the liquid in first conduit element 1410 and may be operative to provide standby functionality similar to the standby functionality of controller 1350 described hereinabove. In this embodiment, controller 1414 may be operative to control the operation of heating elements 1418 based on the temperature sensed by temperature sensor 1426.

It is appreciated that the standby mode of the present invention, including ascertaining a 'near-boiling' temperature and setting standby thresholds as described hereinabove with reference to Figs. 14 - 15, is not limited to the liquid heating vessels shown and described hereinabove and may be utilized with other suitable liquid heating vessels.

It is appreciated that the standby mode of the present invention, may also include a reservoir standby mode, including ascertaining a 'near-boiling' temperature of the liquid in the reservoir and setting reservoir standby thresholds, similar to that described hereinabove with reference to Figs. 14 - 15.
Reference is now made to Figs. 17, 18A, 18B and 19, which are simplified pictorial illustrations of a windshield wiper assembly for use in a vehicle, constructed and operative in accordance with another preferred embodiment of the present invention.

It is appreciated that while the windshield wiper assembly of Figs. 17 - 19 is especially suitable for use with a liquid heating system including a circulation pump, such as the liquid heating system shown in Fig. 13, it may be used with any suitable liquid heating system including a pump.

As seen in Figs. 17, 18A, 18B and 19, the windshield wiper assembly comprises a wiper arm 1600 which is fixed to a shaft 1602 which is preferably arranged for rotation about a rotation axis 1604. Shaft 1602 is preferably driven for reciprocating rotational motion by a conventional wiper drive assembly (not shown), forming part of a conventional motor vehicle. Wiper arm 1600 preferably comprises a first portion 1606 and a second portion 1608. First portion 1606 is preferably connected to shaft 1602, as seen in Fig. 19, and second portion 1608 preferably overlies at least a portion of a wiper blade 1610 and a wiper blade holder 1612.

Alternatively, first portion 1606 of wiper arm 1600 may be arranged for linear movement or linear and rotational movement along a windshield.

Wiper blade holder 1612 holds wiper blade 1610 and is attached to wiper arm 1600 for reciprocating rotational motion therewith; in accordance with a preferred embodiment of the present invention, at least one heat conductive circulation conduit 1620 is provided adjacent to at least one of wiper arm 1600 and wiper blade holder 1612. As seen in Fig. 18A, heat conductive circulation conduits 1622 and 1624 are provided adjacent to wiper arm 1600 and wiper blade holder 1612, respectively.

Heat conductive conduits 1622 and 1624 are connected to each other at ends thereof by connectors 1626 and 1628. Alternatively, heat conductive conduits 1622 and 1624 may be joined to provide continuous circulation of liquid in any suitable manner.

Conduit 1622 preferably includes at least one first conduit portion 1630 located on a first side of wiper arm 1600 and at least one second conduit portion 1632 located on a second side of wiper arm 1600. It is appreciated that as wiper arm 1600 travels along the windshield, first conduit portion 1630 travels in front of wiper arm
1600 when wiper arm 1600 moves in a first direction and first conduit portion 1630 travels in back of wiper arm 1600 when wiper arm 1600 moves in a second direction, opposite the first direction. Second conduit portion 1632 travels along the windshield in back of wiper arm 1600 when wiper arm 1600 moves in the first direction and second conduit portion 1632 travels in front of wiper arm 1600 when wiper arm 1600 moves in the second direction.

Conduit 1624 includes at least one first conduit portion 1640 located on a first side of wiper blade holder 1612 and at least one second conduit portion 1642 located on a second side of wiper blade holder 1612. It is appreciated that as wiper blade holder 1612 travels along the windshield, first conduit portion 1640 travels in front of wiper blade holder 1612 when wiper blade holder 1612 moves in a first direction and first conduit portion 1640 travels in back of wiper blade holder 1612 when wiper blade holder 1612 moves in a second direction, opposite the first direction. Second conduit portion 1642 travels along the windshield in back of wiper blade holder 1612 when wiper blade holder 1612 moves in the first direction and second conduit portion 1642 travels in front of wiper blade holder 1612 when wiper blade holder 1612 moves in the second direction.

In accordance with a preferred embodiment of the present invention, a liquid heating system, such as that described hereinabove with reference to Fig. 13, including at least one heating element, such as heating element 1322 (Fig. 13), operative to heat liquid, and also including a circulation pump, such as circulation pump 1362, is preferably provided for circulating liquid, preferably heated liquid, through heat conductive circulation conduits 1622 and 1624.

Heat conductive circulation conduits 1622 and 1624 preferably define a continuous circulation path to and from the liquid heating system, via the circulation pump, together with a first conduit 1650 and a second conduit 1652. It is appreciated that first conduit 1650 and second conduit 1652 correspond, respectively, to conduits 1364 and 1366, as shown in Fig. 13.

In a preferred embodiment of the present invention, the continuous circulation path, as shown by arrows in Fig. 18A, is defined by a liquid flow from the liquid heating system via the circulation pump to first conduit 1650, to first conduit portion 1630 of circulation conduit 1622, through connector 1626 to second conduit...
portion 1642 of circulation conduit 1624, to first conduit portion 1640 of circulation conduit 1624, to second conduit portion 1642 of circulation conduit 1624, through connector 1628 to second conduit portion 1632 of circulation conduit 1622 and through second conduit 1652 to the liquid heating system.

Alternatively, heat conductive circulation conduit 1624 may be obviated or, as seen in the embodiment of Fig. 18B, may not be connected to heat conductive circulation conduit 1622. In this embodiment, a connector 1660 is provided and the continuous circulation path, as shown by arrows, may be defined by a liquid flow from the liquid heating system via the circulation pump to first conduit 1650, to first conduit portion 1630 of circulation conduit 1622, through connector 1660 to second conduit portion 1632 of circulation conduit 1622 and through second conduit 1652 to the liquid heating system.

In another alternative embodiment of the present invention, first conduit portion 1640 and second conduit portion 1642 of heat conductive circulation conduit 1624 may be located adjacent only a portion of wiper blade holder 1612 that the wiper arm 1600 does not overlie, hi this embodiment, a first and second connector (not shown) connect, respectively, ends of first conduit portions 1630 and 1640, and ends of second conduit portions 1632 and 1642 and the continuous circulation path may be defined by a liquid flow from the liquid heating system via the circulation pump to first conduit 1650, to first conduit portion 1630 of circulation conduit 1622, through the first connector to first conduit portion 1640 of circulation conduit 1624, to second conduit portion 1642 of circulation conduit 1624, through the second connector to second conduit portion 1632 of circulation conduit 1622 and through second conduit 1652 to the liquid heating system.

In yet another alternative embodiment of the present invention, the continuous circulation path may be defined by a liquid flow from the liquid heating system via the circulation pump to first conduit 1650, to first conduit portion 1630 of circulation conduit 1622, to second conduit portion 1632 of circulation conduit 1622, through a first connecting conduit (not shown) to first conduit portion 1640 of circulation conduit 1624, to second conduit portion 1642 of circulation conduit 1624, through a second connecting conduit (not shown), through second conduit 1652 to the liquid heating system.
In another alternative embodiment, heat conductive circulation conduit 1622 may be obviated and the continuous circulation path may be defined by a liquid flow from the liquid heating system via the circulation pump to first conduit 1650, through a first connecting conduit (not shown) to second conduit portion 1642 of circulation conduit 1624, to first conduit portion 1640 of circulation conduit 1624, to second conduit portion 1642 of circulation conduit 1624, through a second connecting conduit (not shown), through second conduit 1652 to the liquid heating system.

As described hereinabove, preferably, a single circulation path is defined for heat conductive circulation conduits 1622 and 1624. Alternatively, more than one circulation pump defining more than one circulation path may be provided. It is appreciated that any suitable circulation path may be defined whereby liquid flows through heat conductive circulation conduits along at least a portion of wiper arm 1600 or wiper blade holder 1612.

It is appreciated that, even though the illustrated embodiments described hereinabove show circulation paths originating and terminating in a liquid heating vessel, the circulation paths of the present invention may alternatively originate and terminate in a vehicle reservoir including a heating element.

First conduit portions 1630 and 1640 and second conduit portions 1632 and 1642 are preferably formed at least partially of a heat conductive material and are preferably situated such that at least the portion facing outwardly from wiper arm 1600 and wiper blade holder 1612 is heat conductive. It is appreciated that heat conductive circulation conduits 1622 and 1624 may be of any suitable cross-section and/or diameter and may provide any suitably sized heat conductive outwardly facing portion. It is appreciated that heat conductive circulation conduits 1622 and 1624 need not be of a uniform diameter and/or cross-section along the entire length thereof. In a preferred embodiment of the present invention, the width of the heat conductive outwardly facing portion may approximate the width of the wiper arm 1600 and/or wiper blade holder 1612. In another preferred embodiment, the heat conductive outwardly facing portion may fill any portion of the area between wiper arm 1600 and wiper blade 1610.

Alternatively, the heat conductive outwardly facing portion may also overlap a portion of wiper blade 1610.

Conduits 1650 and 1652 and the connecting conduits are preferably
formed of a non heat conductive material and may be defined, at least along a portion thereof, in a unitary conduit element, wherein conduits 1650 and 1652 are preferably generally surrounded by a thermal insulation layer. It is appreciated that the unitary conduit element may also include an additional conduit, similar to conduit 1368 (Fig. 13) which may supply liquid to a conventional vehicle liquid spray head. It is further appreciated that the system of the present invention may also include at least one electrical heating element heating at least one of conduits 1650 and 1652 and the additional conduit.

The system of the present invention may also include conduits and connectors, such as flexible areas, such as flexible areas 1670, to provide for smooth connection therebetween and to insure appropriate alignment with the wiper arm 1600 and wiper blade holder 1612 in all orientations.

It is appreciated that similar conduit portions may also be provided for circulation of liquid adjacent wiper blade 1610 and/or for circulation of liquid adjacent to spray nozzles. It is appreciated that the system of the present invention may also include an electrical heating element heating a supply conduit supplying liquid to the spray nozzles.

Heat conductive circulation conduits 1622 and 1624 thereby provide heated surfaces that are in contact with snow and/or ice that may have become deposited on the windshield and may be operative to melt the snow and/or ice as the wipers move along the windshield. It is appreciated that in extreme conditions, where a thick layer of snow and/or ice has accumulated on the windshield, the windshield wiper assembly of the present invention, as described hereinabove, will provide for the melting of a layer thereof closest to the windshield which will allow for easier breakup and removal of the rest of the snow and/or ice layer by a vehicle operator.

Reference is now made to Fig. 20, which is a simplified partially pictorial illustration of a windshield wiper assembly for use in a vehicle constructed and operative in accordance with another preferred embodiment of the present invention.

As seen in Fig. 20, the windshield wiper assembly comprises a wiper arm 1700 which is fixed to a shaft (not shown) which is preferably arranged for rotation about a rotation axis (not shown). The shaft is preferably driven for reciprocating
rotational motion by a conventional wiper drive assembly (not shown), forming part of
a conventional motor vehicle. Wiper arm 1700 preferably comprises a first portion 1706
and a second portion 1708. First portion 1706 is preferably connected to the shaft and
second portion 1708 preferably overlies at least a portion of a wiper blade 1710 and a
wiper blade holder 1712.

Alternatively, first portion 1706 of wiper arm 1700 may be arranged for
linear movement or linear and rotational movement along a windshield.

Wiper blade holder 1712 holds wiper blade 1710 and is attached to wiper
arm 1700 for reciprocating rotational motion therewith. In accordance with a preferred
embodiment of the present invention, windshield wiper assembly may include at least
one electrical heating element 1720 operative to heat wiper arm 1700 and/or wiper
blade holder 1712. In the illustrated embodiment, multiple electrical heating elements
1722 are provided to heat wiper arm 1700 and multiple electrical heating elements 1724
are provided to heat wiper blade holder 1712. It is appreciated that electrical current
may be provided to heating elements 1722 and 1724 in any suitable fashion, as known
in the art.

It is appreciated that the system of the present invention may also include
an electrical heating element heating a supply conduit supplying liquid to spray nozzles.

As seen in Fig. 20, wiper arm 1700 and wiper blade holder 1712 include
at least one heat conductive outer wall 1730, preferably in an outward facing area.

It is appreciated that, although the illustrated embodiment shows
electrical heating elements 1722 and 1724 located internally to wiper arm 1700 and
wiper blade holder 1712, respectively, electrical heating elements 1722 and 1724 may
alternatively be located externally to wiper arm 1700 and wiper blade holder 1712,
respectively.

Heat conductive outer wall 1730 thereby provides a heated surface that is
in contact with snow and/or ice that may have become deposited on the windshield and
is operative to melt the snow and/or ice as the wipers move along the windshield. It is
appreciated that in extreme conditions, where a thick layer of snow and/or ice has
accumulated on the windshield, the windshield wiper assembly of the present invention,
as described hereinabove, will provide for the melting of a layer thereof closest to the
windshield which will allow for easier breakup and removal of the rest of the snow
and/or ice layer by a vehicle operator.

In another preferred embodiment of the present invention, a windshield wiper assembly, similar to the windshield wiper assembly of Fig. 20, may include at least one heat conductive circulation conduit, similar to the windshield wiper assembly described in reference to Figs. 17 - 19. In this embodiment, for example, wiper arm 1700 may be provided with an internal or external heating element, such as heating element 1722 of Fig. 20, and wiper blade holder 1712 may be provided with at least one heat conductive circulation conduit, such as heat conductive circulation conduit 1624 of Fig. 18A. Alternatively, wiper arm 1700 may be provided with at least one heat conductive circulation conduit, such as heat conductive circulation conduit 1622 of Fig. 18A, and wiper blade holder 1712 may be provided with an internal or external heating element, such as heating element 1724 of Fig. 20. Alternatively, wiper arm 1700 and/or wiper blade holder 1712 may include an internal or external heating element, such as heating element 1720 of Fig. 20, and at least one heat conductive circulation conduit, such as heat conductive circulation conduit 1620 of Fig. 18A.

It is appreciated that in the embodiments of the present invention, particularly those described hereinabove with reference to Figs. 17 - 20, the vehicle may also include a heatable drain area, such as a heatable drain pipe, adjacent to the shaft to allow for drainage of melted snow and/or ice.

Reference is now made to Fig. 21, which is a simplified flow chart of a method for operating a windshield wiper assembly in accordance with another preferred embodiment of the present invention, particularly useful with the systems described hereinabove with reference to Figs. 17 - 20.

In accordance with a preferred embodiment of the present invention, a windshield wiper actuator includes a wiper controller and a wiper motor operative to actuate at least one windshield wiper. It is appreciated that the wiper controller may be a standalone wiper controller, or may be a wiper controller in communication with a vehicle computer or may be integrated into a vehicle computer or any combination thereof.

The wiper controller of the present invention is preferably operative to effectively and efficiently control the wiper motor and wipers to clean the windshield and to prevent potential overheating damage to the wiper motor when the wiper
assembly has become 'blocked'. As seen in Fig. 21, in accordance with a preferred embodiment of the present invention, the wiper controller is operative to select a blocked threshold level relative to an operational parameter of the wiper assembly, such as a torque of the wiper arm, an estimated current provided to the motor or any other suitable operational parameter. It is appreciated that the blocked threshold level selected by the wiper controller may be a constant value or may be calculated as a function of any suitable input available to the wiper controller, as described further hereinbelow.

As seen further in Fig. 21, the wiper controller is preferably operative to sense that the wiper assembly has become 'blocked' and 'unblocked' by measuring the operational parameter and comparing it to the blocked threshold level. When the operational parameter exceeds the blocked threshold level, the wiper controller senses a 'blocked' state of the wiper assembly, and when the operational parameter does not exceed the blocked threshold level, the wiper controller senses an 'unblocked' state.

Alternatively, the operational parameter may be an absolute value of the rotational movement of a shaft encoder included in the wiper assembly or other operational parameter, wherein when the operational parameter is less than the blocked threshold level the wiper controller senses a 'blocked' state of the wiper assembly, and when the operational parameter exceeds than the blocked threshold level, the wiper controller senses an 'unblocked' state.

Preferably, the 'blocked' state is reached when the wiper is unable to reach a limit of travel along the windshield according to a normal operating mode. The 'blocked' state is generally reached when the wiper blade is frozen to the windshield and/or the wiper assembly is blocked by a large buildup of snow and/or ice or another substance, such as mud.

In accordance with a preferred embodiment of the present invention, when the wiper controller senses an 'unblocked' state it is operative to operate the wiper motor in accordance with a first operating mode, typically a conventional operating mode. When the wiper controller senses a 'blocked' state it is operative to operate the wiper motor in accordance with a second operating mode, such as a modified operating mode as described hereinbelow.

In a preferred embodiment of the present invention, when operating in the modified operating mode, the wiper controller is operative to stop the movement of
the wiper assembly, for a time interval, such as by reducing a current provided to the motor to zero, while heating areas adjacent to the wiper arm, the wiper blade holder and/or the wiper blade, through heat conductive circulation conduits and/or at least one heating element, such as the heat conductive circulation conduits and heating elements described hereinabove with reference to Figs. 17 - 20. This heating helps melt snow and/or ice that may be blocking the wiper. The wiper controller is operative to change the direction of the wiper at the end of the time interval.

Alternatively, when operating in the modified operating mode, the wiper controller may be operative to set a maximum operational level, preferably a level less than or equal to the blocked threshold level, and to set the current provided to the motor to a level no greater than the maximum operational level, while heating areas adjacent to the wiper arm, the wiper blade holder and/or the wiper blade, for a time interval. In this embodiment, the wiper controller is preferably operative to monitor the operational parameter to ascertain if the wiper has become 'unblocked', by comparing the operational parameter to the maximum operational level, during the time interval. If the wiper controller senses that the wiper has not become 'unblocked', the wiper controller is operative to change the direction of the wiper at the end of the time interval. If the wiper controller senses that the wiper has become 'unblocked', it then resumes normal operation until a 'blocked' state is again sensed. If the wiper controller then senses that the wiper has again become 'blocked', it is again operative to set the current provided to the motor the wiper blade to the maximum operational level, for a time interval. It is appreciated that the wiper controller may be operative to select a predetermined maximum number of 'blocked' and 'unblocked' cycles to be executed before changing direction of the wiper.

In accordance with another alternative embodiment, when operating in the modified operating mode, the wiper controller may be operative to set a time interval to increase the current provided to the motor to a maximum operational level greater than the blocked threshold level. In this embodiment, the wiper controller is preferably operative to monitor the operational parameter and compare the operational parameter to the maximum operational level, to ascertain if the wiper has become 'unblocked' during the time interval. If the wiper controller senses that the wiper has become 'unblocked', it then resumes normal operation. If the wiper controller senses
that the wiper has not become 'unblocked', the wiper controller is operative to change the direction of the wiper at the end of the time interval.

In accordance with yet another alternative embodiment, when operating in the modified operating mode, the wiper controller may be operative to set a time interval and to provide a rapid back and forth movement of the wiper over a small area adjacent to location of the wiper when the blocked state was sensed for the duration of the time interval. In this embodiment, the wiper controller is preferably operative to repeatedly change the direction of the wiper for very short periods. In this embodiment, the wiper controller is preferably operative to ascertain if the wiper has become 'unblocked' at the end of the time interval. If the wiper controller senses that the wiper has become 'unblocked', it then resumes normal operation. If the wiper controller senses that the wiper has not become 'unblocked', the wiper controller is operative to change the direction of the wiper at the end of the time interval.

As described hereinabove, it is appreciated that the maximum operational level may be greater than, equal to or less than the blocked threshold level.

It is appreciated that the wiper controller may be operative, when operating in the modified operating mode, to combine one or more of the above embodiments, as suitable, or may provide any other suitable modified operating mode to operate the wiper.

It is appreciated that, although the embodiment described hereinabove includes a system with a single wiper motor, wiper assembly may include multiple wiper motors each independently driving a wiper assembly and that the wiper controller may monitor 'blocked' and 'unblocked' states of each wiper motor and associated wiper assembly individually. Additionally, it is appreciated that each of the multiple wiper motors may be associated with wiper assemblies wiping the same vehicle surface and/or different vehicle surfaces.

It is appreciated that the blocked threshold level selected by the wiper controller may be a constant value or may be calculated as a function of any suitable input available to the wiper controller, such as wiper arm position relative to a limit of travel of the wiper arm.

The wiper controller is preferably operative to measure or calculate the operational parameter using any suitable method. In accordance with a preferred
embodiment of the present invention the wiper controller is operative to select a measured or an estimated torque of the wiper assembly as the operational parameter. As is known in the art, an estimated torque of the wiper assembly may be provided by a torque sensor or, alternatively, may be calculated by the wiper controller as a function of the current supplied to the motor or any other suitable method.

 Preferably, the wiper controller sets the blocked threshold level, the maximum operational level and the time interval based on the operational parameters of the wiper motor as provided by the wiper motor manufacturer and other 'real-time' vehicle parameters available to the wiper controller, such as the wiper motor temperature. It is appreciated that, preferably, the time interval and the maximum operational level are in inverse relationship with one another. It is appreciated that the wiper controller may use any suitable method for setting the blocked threshold level, the time interval and the maximum operational level.

 It is appreciated that the term "torque," as used in context of the present patent application and in the claims, may refer to an estimated value for the torque of a motor, calculated by any suitable method, or may refer to a value or an estimated value provided by a torque sensor. For example, the estimated value for the torque may be calculated as a function of current consumption of the motor.

 It is appreciated that operating modes described hereinabove, with reference to Fig. 21, are suitable for use with any liquid heating system, and are particularly suitable for use with the systems described hereinabove with reference to Figs. 17 - 20.

 It will be appreciated by persons skilled in the art that the present invention is not limited by what has been particularly shown and described hereinabove. Rather the scope of the present invention includes both combinations and subcombinations of the various features described hereinabove as well as variations and modifications which would occur to persons skilled in the art upon reading the specification and which are not in the prior art.
CLAIMS

1. Apparatus for supplying heated liquid for use in cleaning a vehicle surface comprising:
   a liquid container having an inlet through which a liquid is received from a reservoir and an outlet through which the liquid is discharged for cleaning said vehicle surface, said liquid container including:
   a first heating chamber;
   a second heating chamber; and
   a heat transfer element in direct thermal contact with said first heating chamber and said second heating chamber and defining at least a portion of an external wall of said liquid container; and
   a heating element adjacent said heat transfer element operative to heat said heat transfer element and thereby heat the liquid in said first heating chamber and said second heating chamber.

2. Apparatus according to claim 1 and wherein said liquid container also includes at least one enclosing element attached to said heat transfer element.

3. Apparatus according to claim 2 and wherein said heat transfer element defines a cover of said at least one enclosing element.

4. Apparatus according to claim 1 and wherein said first heating chamber includes a rounded end portion.

5. Apparatus according to claim 1 and also comprising at least one insulating cover assembly including a volume maintained under a vacuum.

6. Apparatus according to claim 1 and wherein at least a portion of said at least one enclosing element is formed of rubber.
7. A method for supplying heated liquid for use in cleaning a vehicle surface comprising:
   providing a liquid container for heating a liquid, said liquid container including a first heating chamber, a second heating chamber and a heat transfer element in direct thermal contact with said first heating chamber and said second heating chamber and defining at least a portion of an external wall of said liquid container;
   receiving a liquid into said first heating chamber and said second heating chamber;
   heating said heat transfer element thereby heating the liquid in said first heating chamber and said second heating chamber through said heat transfer element; and
   discharging said liquid through an outlet onto said vehicle surface.

8. Apparatus for supplying heated liquid for use in cleaning a vehicle surface, comprising:
   a vessel, having an inlet through which a liquid is received from a reservoir and an outlet through which the liquid is discharged for cleaning said vehicle surface, said vessel including a first heating chamber and a second heating chamber;
   a heat transfer cover, in direct thermal contact with said first heating chamber and said second heating chamber, operative to heat the liquid in said first heating chamber and said second heating chamber; and
   a heating element adjacent said heat transfer cover operative to heat said heat transfer cover.

9. A method for supplying heated liquid for use in cleaning a vehicle surface comprising:
   providing a vessel for heating a liquid, said vessel including a first heating chamber and a second heating chamber;
   receiving a liquid into said vessel so that said liquid flows into said first heating chamber and said second heating chamber;
   heating a heat transfer cover in direct thermal contact with said first heating chamber and said second heating chamber, thereby heating the liquid in said
first heating chamber and said second heating chamber through said heat transfer cover; and
discharging said liquid through an outlet onto said vehicle surface.

10. A method for supplying heated liquid for use in cleaning a vehicle surface comprising:
receiving a liquid into a vessel;
heating said liquid in said vessel; and
discharging said liquid through an outlet onto said vehicle surface,
said heating said liquid comprising:
providing at least one heating element in thermal communication with said vessel; and
operating said at least one heating element in one of multiple operating modes including a heating element standby mode,
said heating element standby mode including:
ascertaining a near-boiling temperature of said liquid;
setting at least one pair of standby mode temperature thresholds, based at least partially on said near-boiling temperature;
measuring a temperature of said liquid; and
controlling said at least one heating element based on said temperature and said temperature thresholds.

11. Apparatus for supplying heated liquid for use in cleaning a vehicle surface, comprising:
a vessel, having an inlet through which a liquid is received from a reservoir and an outlet through which the liquid is discharged for cleaning said vehicle surface;
at least one heating element in thermal communication with said vessel;
at least one temperature sensor operative to measure a temperature of said liquid in said vessel; and
a controller operative to operate said at least one heating element in one of multiple operating modes including a standby mode,
said standby mode including:
ascertaining a near-boiling temperature of said liquid;
setting at least one pair of standby mode temperature thresholds, based
at least partially on said near-boiling temperature; and
controlling said at least one heating element based on said temperature
and said temperature thresholds.

12. Apparatus according to claim 11 and wherein said setting is based at least
partially on input from at least one additional sensor.

13. Apparatus according to claim 11 and wherein:
said controller is operative to select a primary temperature sensor
including said at least one temperature sensor; and
said at least one pair of standby thresholds includes a pair of standby
thresholds for each sensor of said at least one temperature sensor.

14. Apparatus according to claim 11 and also comprising a circulation pump
and wherein said setting is based at least partially on an operating mode of said
circulation pump.

15. Apparatus according to claim 11 and also comprising an RP actuator in
communication with said controller, said controller being operative, upon receipt of a
standby mode actuation from said RF actuator, to operate said at least one heating
element in said standby mode.

16. Apparatus for supplying heated liquid for use in cleaning a vehicle
surface, comprising:
a liquid container, having an inlet through which a liquid is received from
a reservoir and an outlet through which the liquid is discharged for cleaning said vehicle
surface;
a heating element operative to heat the liquid in said liquid container; and
at least one insulating portion overlying said liquid container,
said at least one insulating portion including a volume maintained under a vacuum.

17. Apparatus according to claim 16 and wherein said at least one insulating portion comprises at least one insulating cover assembly including said volume maintained under a vacuum.

18. Apparatus according to claim 16 and also comprising at least one insulation layer between said liquid container and said at least one insulating portion.

19. A method for supplying heated liquid for use in cleaning a vehicle surface comprising:
   providing a liquid container for heating a liquid and at least one insulating portion overlying said liquid container, said at least one insulating portion including a volume maintained under a vacuum;
   receiving a liquid into said liquid container;
   heating the liquid in said liquid container; and
   discharging said liquid through an outlet onto a vehicle surface to be cleaned.

20. Apparatus for de-icing a vehicle surface, comprising:
   a wiper assembly including:
   a wiper driver assembly operative to move said wiper assembly along said vehicle surface;
   a wiper arm;
   a wiper blade holder; and
   a wiper blade;
   a vessel containing a liquid;
   at least one heating element for heating said liquid in said vessel;
   a controller operative to control said at least one heating element;
   at least one heat conductive circulation conduit adjacent to at least one of said wiper arm and said-wiper blade holder; and
a circulation pump operative to circulate liquid from said vessel through said at least one heat conductive circulation conduit.

21. Apparatus according to claim 20 and wherein:

said at least one of said wiper arm and said wiper blade holder is operative to travel along said vehicle surface in a first direction and in a second direction opposite said first direction;

said at least one heat conductive circulation conduit includes at least one first heat conductive portion and at least one second heat conductive portion;

said at least one first heat conductive portion is operative to travel along said vehicle surface in front of said wiper arm when said wiper arm moves in said first direction and in back of said wiper arm when said wiper arm moves in said second direction; and

said at least one second heat conductive portion is operative to travel along said vehicle surface in back of said wiper arm when said wiper arm moves in said first direction and in front of said wiper arm when said wiper arm moves in said second direction.

22. Apparatus according to claim 20 and also comprising at least one non heat conductive circulation conduit in fluid communication with said circulation pump and said at least one heat conductive circulation conduit.

23. Apparatus according to claim 20 and wherein at least a portion of said at least one heat conductive circulation conduit is formed of a flexible material.

24. Apparatus according to claim 20 and wherein said at least a portion of said at least one heat conductive circulation conduit is integrally formed with said wiper arm.

25. Apparatus according to claim 20 and wherein said at least a portion of said at least one heat conductive circulation conduit is integrally formed with said wiper blade holder.
26. Apparatus according to claim 20 and also comprising at least one additional heating element for directly heating at least one of at least a portion of said wiper arm and at least a portion of said wiper blade holder.

27. Apparatus according to claim 26 and wherein said at least one additional heating element is also operative to heat said wiper blade.

28. Apparatus according to claim 20 and wherein said at least one heat conductive circulation conduit forms part of a continuous circulation path to and from said vessel.

29. A method for de-icing a vehicle surface, comprising:

providing a wiper assembly including a wiper arm, a wiper blade holder, a wiper blade and a wiper driver assembly operative to move said wiper assembly along said vehicle surface;

providing at least one heat conductive circulation conduit adjacent to at least one of said wiper arm and said wiper blade holder;

heating a liquid in a vessel;

circulating liquid from said vessel through said at least one heat conductive circulation conduit; and

moving said wiper assembly along said vehicle surface.

30. A method according to claim 29 and wherein said at least one of said wiper arm and said wiper blade holder is operative to travel along said vehicle surface in a first direction and in a second direction opposite said first direction;

said at least one heat conductive circulation conduit includes at least one first heat conductive portion and at least one second heat conductive portion;

said at least one first heat conductive portion is operative to travel along said vehicle surface in front of said wiper arm when said wiper arm moves in said first direction and in back of said wiper arm when said wiper arm moves in said second direction; and
said at least one second heat conductive portion is operative to travel along said vehicle surface in back of said wiper arm when said wiper arm moves in said first direction and in front of said wiper arm when said wiper arm moves in said second direction.

31. Apparatus for supplying heated liquid for use in cleaning a vehicle surface comprising:

- a vessel, having an inlet through which a liquid is received from a reservoir and an outlet through which the liquid is discharged for cleaning said vehicle surface;
- a heating unit operative to heat said liquid in said vessel;
- a dirt sensor providing a dirt level output; and
- a controller operative to generate at least one of a non-spray indication output signal and at least two different spray indication output signals at least partially in response to said dirt level output.

32. Apparatus according to claim 31 and wherein said controller is operative to compare said dirt level output to at least two different dirt level thresholds.

33. Apparatus according to claim 31 and wherein said at least two different spray indication output signals include signals that generate at least two different heated spraying cycles.

34. Apparatus according to claim 31 and also comprising at least one additional sensor operative to provide at least one additional input to said controller and wherein said controller is also operative to base said at least two different spray indication output signals at least partially on said at least one additional input.

35. Apparatus according to claim 34 and wherein said at least one additional sensor includes a temperature sensor and said at least one additional input includes a temperature sensed by said temperature sensor.
36. Apparatus according to claim 34 and wherein said controller is also operative to calculate at least one additional parameter and to base said at least two different spray indication output signals at least partially on said at least one additional parameter.

37. Apparatus according to claim 36 and wherein said at least one additional parameter includes a rate of change of said temperature sensed by said temperature sensor.

38. Apparatus according to claim 31 and wherein said controller is also operative to calculate at least one additional parameter and to base said at least two different spray indication output signals at least partially on said at least one additional parameter.

39. Apparatus according to claim 38 and wherein said at least one additional parameter includes a rate of change of said dirt level output.

40. A method for supplying heated liquid for use in cleaning a vehicle surface comprising:

- providing a vessel for heating a liquid;
- receiving a liquid into said vessel;
- heating said liquid;
- measuring a dirt level adjacent said vehicle surface and providing a dirt level output; and
- providing at least one of a non-spray indication output signal and at least two different spray indication output signals at least partially in response to said dirt level output.

41. Apparatus for de-icing a vehicle surface, comprising:

- a wiper assembly including:
  - at least one wiper for wiping said vehicle surface, said wiper operative to move along said vehicle surface; and
a wiper actuator including:
a motor which actuates said at least one wiper; and
a wiper controller operative to operate said motor in at least a first
operational mode and a second operational mode,
said wiper controller being operative:
to ascertain if said at least one wiper is blocked or unblocked;
to operate said motor in accordance with said first operational mode
when said at least one wiper is unblocked; and
to operate said motor in accordance with said second operational mode
when said at least one wiper is blocked.

42. A method for de-icing a vehicle surface comprising:
providing a wiper assembly including at least one wiper for wiping said
vehicle surface and a wiper actuator system including a motor which actuates said at
least one wiper and a wiper controller operative to control said motor;
ascertaining if said at least one wiper is blocked or unblocked;
operating said motor in accordance with a first operational mode when
said at least one wiper is unblocked; and
operating said motor in accordance with a second operational mode when
said at least one wiper is blocked.

43. A method according to claim 42 and wherein said ascertaining includes:
setting a blocked threshold level;
measuring an operational parameter of said wiper assembly; and
comparing said operational parameter to said blocked threshold level.

44. A method according to claim 43 and wherein said blocked threshold level
is a function of an angle of movement of said at least one wiper.

45. A method according to claim 43 and wherein said second operational
mode includes:
setting a maximum operational level to be applied to said motor;
applying an operational input less than or equal to said maximum
operational level for a time interval;
ascertaining, at the end of said time interval, if said at least one wiper is
blocked or unblocked; and
if said at least one wiper is blocked, changing the direction of said at least
one wiper.

46. A method according to claim 45 wherein said maximum operational level
is greater than said blocked threshold level.

47. A method according to claim 45 wherein said maximum operational level
is zero.

48. A method according to claim 45 wherein said maximum operational level
is less than said threshold level and said ascertaining at the end of said time interval
includes:
measuring an operational parameter of said wiper assembly; and
comparing said operational parameter to said maximum operational level.

49. A method according to claim 42 and wherein said second operational
mode includes:
setting a maximum operational level to be applied to said motor;
applying an operational input less than or equal to said maximum
operational level for a time interval; and
changing the direction of said at least one wiper at the end of said time
interval.

50. A method according to claim 42 and wherein said second operational
mode includes:
setting a time interval;
providing rapid back and forth movement of said at least one wiper over a small area adjacent to a location of said at least one wiper when said at least one wiper becomes blocked, for said time interval;

ascertaining, at the end of said time interval, if said at least one wiper is blocked or unblocked; and

if said at least one wiper is blocked, changing the direction of said at least one wiper.

51. A thermal fuse comprising:

an electrical power supply connection including:

a first conductive portion;

a second conductive portion in electrical communication with said first conductive portion, said second conductive portion being operative to melt in response to being heated above a predetermined temperature; and

an expanding non electrically conductive portion operative to expand and displace said second conductive portion out of electrical communication with said first conductive portion in response to heating of said second conductive portion above a predetermined temperature, thus interrupting supply of electrical power through said electrical power supply connection.

52. A thermal fuse according to claim 51 and wherein said expanding non electrically conductive portion is operative to expand and displace said second conductive portion regardless of the orientation of said thermal fuse.

53. A liquid collection and reuse system for use with a vehicle including:

at least one liquid collector associated with said vehicle; and

at least one collection reservoir associated with said vehicle, having an inlet through which a liquid is received from said at least one liquid collector.

54. A liquid collection and reuse system according to claim 53 wherein said collection reservoir includes an outlet through which the liquid is discharged for cleaning a vehicle surface.
55. A liquid collection and reuse system according to claim 53 and also comprising a vessel for heating said liquid, said vessel having an inlet through which a liquid is received from said collection reservoir and an outlet through which the liquid is discharged for cleaning a vehicle surface.

56. A liquid collection and reuse system according to claim 53 wherein said at least one liquid collector is operative to collect liquid drainage from a vehicle air conditioning unit.

57. A liquid collection and reuse system according to claim 53 and also comprising at least one filter operative to receive unfiltered liquid from said at least one liquid collector and to provide filtered liquid to said at least one collection reservoir.

58. A liquid collection and reuse system according to claim 53 and also comprising at least one pre-filtration valve.

59. A liquid collection and reuse system according to claim 58 and also comprising a drain and wherein said at least one pre-filtration valve is operative in a filter open position to allow unfiltered liquid to reach said at least one filter and in a filter closed position directs unfiltered liquid to said drain.

60. A liquid collection and reuse system according to claim 53 and also comprising a liquid flow controller operative to control a liquid flow based on a liquid level sensed by a liquid level sensor.

61. A liquid collection and reuse system according to claim 60 and also comprising a vehicle reservoir operative to supply liquid to a liquid heating unit and wherein said liquid level sensor measures a liquid level within said vehicle reservoir and said liquid flow controller is operative to provide liquid to said vehicle reservoir based on said liquid level sensed by said liquid level sensor.
62. A liquid collection and reuse system according to claim 53 and also comprising:
   at least one additional reservoir; and
   a liquid flow controller operative to control multiple liquid flows through
   said liquid collection and reuse system.

63. A liquid collection and reuse system according to claim 62 and wherein a
   liquid in said at least one additional reservoir is a different liquid than a liquid in said at
   least one collection reservoir.

64. A liquid collection and reuse system according to claim 63 and wherein
   said liquid flow controller is operative to provide an optimal mix of liquids from said at
   least one collection reservoir and said at least one additional reservoirs.

65. A liquid collection and reuse system according to claim 62 and wherein
   said at least one additional reservoir and said at least one collection reservoir contain the
   same liquid.

66. A method for liquid collection and reuse including:
   collecting liquid utilizing at least one liquid collector associated with a
   vehicle; and
   receiving said liquid into at least one collection reservoir located in said
   vehicle.

67. A method according to claim 66 and also comprising discharging said
   liquid through an outlet onto a vehicle surface to be cleaned.

68. A method according to claim 66 and also comprising filtering said liquid
   prior to said receiving.

69. Apparatus for supplying heated liquid for use in cleaning a vehicle
   surface, comprising:
a vessel, having an inlet through which a liquid is received from a reservoir and an outlet through which the liquid is discharged for cleaning said vehicle surface, said vessel including a rounded end portion;

a heat transfer cover operative to heat the liquid, said heat transfer cover including a curved cross section portion formed on an inner facing surface thereof, said curved cross section portion including multiple protruding sections each comprising a curved portion; and

a heating element adjacent said heat transfer cover operative to heat said heat transfer cover.

70. Apparatus according to claim 69 and wherein said rounded end portion, said curved cross section portion and said curved portions of said heat transfer cover provide for liquid circulation within said vessel that generates improved heat transfer from the heat transfer cover to the liquid contained in said vessel.

71. Apparatus according to claim 69 and wherein said rounded end portion, said curved cross section portion and said curved portions of said heat transfer cover provide for liquid circulation within said vessel that generates improved uniformity of the temperature of the liquid contained in said vessel.

72. Apparatus according to claim 69 and wherein said rounded end portion, said curved cross section portion and said curved portions of said heat transfer cover generate a generally circular flow within said vessel at a first temperature differential between said liquid contained within said vessel and portions of said heat transfer cover in contact with said liquid.

73. Apparatus according to claim 69 and wherein said rounded end portion said curved cross section portion and said curved portions of said heat transfer cover generate multiple generally circular flows within said vessel at a second temperature differential between said liquid contained within said vessel and portions of said heat transfer cover in contact with said liquid.
74. A method for supplying heated liquid for use in cleaning a vehicle surface, comprising:
providing a vessel for heating a liquid, said vessel including a rounded end portion;
receiving a liquid into said vessel so that said liquid flows into said rounded end portion;
heating a heat transfer cover overlying said vessel thereby heating the liquid in said rounded end portion through said heat transfer cover, said heat transfer cover including a curved cross section portion formed on an inner facing surface thereof, said curved cross section portion including multiple protruding sections each comprising a curved portion; and
discharging said liquid through an outlet onto said vehicle surface.

75. Apparatus for de-icing a vehicle surface, comprising:
a wiper assembly including:
a wiper driver assembly operative to move said wiper assembly along said vehicle surface;
a wiper arm;
a wiper blade holder; and
a wiper blade; and
at least one heating element for directly heating at least one of at least a portion of said wiper arm and at least a portion of said wiper blade holder.

76. Apparatus according to claim 75 and wherein said at least one heating element is also operative to heat said wiper blade.

77. Apparatus according to claim 75 and also comprising a controller operative to control said at least one heating element.

78. A method for de-icing a vehicle surface, comprising:
providing a wiper assembly including a wiper arm, a wiper blade holder, a wiper blade and a wiper driver assembly operative to move said wiper assembly along said vehicle surface;
heating at least one of at least a portion of said wiper arm and at least a portion of said wiper blade holder; and
moving said wiper assembly along said vehicle surface.

79. Apparatus for supplying heated liquid for use in cleaning a vehicle surface comprising:
a vessel, having an inlet through which a washing fluid is received from a reservoir and an outlet through which the fluid is discharged for cleaning said vehicle surface;
a heating element for heating the fluid in the vessel;
a controller for controlling operation of said apparatus; and
an RF actuator in communication with said controller, said RF actuator operative to initiate communication with said controller and to uniquely identify said RF actuator to said controller.

80. Apparatus according to claim 79 and wherein said controller is operative, upon receipt of a standby mode actuation from said RF actuator, to operate said apparatus in accordance with a heating element standby mode.

81. Apparatus according to claim 79 and wherein said controller is operative, upon receipt of an automatic mode actuation from said RF actuator, to operate said apparatus in accordance with an automatic mode.

82. Apparatus according to claim 79 and wherein said controller is operative, upon receipt of an off command from said RF actuator, to place said apparatus in an off mode.
83. Apparatus according to claim 79 and wherein said controller is operative to ignore commands from said RF actuator when an engine of said vehicle is in an off state.

84. Apparatus according to claim 83 and wherein said controller is operative to monitor the state of said engine of said vehicle by measuring a voltage level of a battery of said vehicle.

85. Apparatus according to claim 84 and wherein said vehicle is in an off state when said voltage level is less than a predetermined level.

86. Apparatus for supplying heated liquid for use in cleaning a vehicle surface comprising:
   a vessel, having an inlet through which a liquid is received from a reservoir and an outlet through which the liquid is discharged for cleaning said vehicle surface; and
   a heating element operative to heat the liquid in said vessel, at least a portion of said vessel being formed of rubber.
FIG. 9A

IMMEDIATE SPRAY MODE

START

FIRST SPRAY

WAITING TIME $T_{IW}$ OVER?

NO

YES

SECOND SPRAY

END
START

TURN ON HEATING ELEMENT(S)

FIG. 14

OBTAIN TEMP₁

NO

TEMP₁ ≥ PREDETERMINED MINIMUM?

HEAT LIQUID

OBTAIN TEMP₁

NO

TEMP₁ ≥ PREDETERMINED MINIMUM?

YES

(NO)

TEMP₂ - TEMP₁ < MINIMUM

SET TEMP₁ = TEMP₂

WAIT FOR PREDETERMINED INTERVAL

OBTAIN TEMP₂

SET TEMP₁ = TEMP₂

YES

(NO)

(TEMP₂ - TEMP₁) < PREDETERMINED STABILITY VALUE

SET NEAR-BOILING TEMPERATURE TO PREDETERMINED VALUE

ASCERTAIN NEW NEAR-BOILING TEMPERATURE AFTER A PREDETERMINED TIME INTERVAL

END

(TEMP₂ - TEMP₁) ≥ MINIMUM

HEAT LIQUID FOR PREDETERMINED INTERVAL

OBTAIN TEMP₂

SET NEAR-BOILING TEMPERATURE = TEMP₂

TURN OFF HEATING ELEMENT(S)
START

NO

IGNITION ON

YES

NO

V > MIN_V

YES

ASCERTAIN NEAR-BOILING TEMPERATURE

NO

IMMEDIATE SPRAY ACTUATED?

YES

IMMEDIATE SPRAY

HIGH TEMP. SPRAY ACTUATED?

YES

HIGH TEMP. SPRAY

< LOWER SENSED TEMPERATURE TO UPPER & LOWER THRESHOLD

> LOWER & < UPPER

INCREASE TEMPERATURE

MAINTAIN TEMPERATURE

TURN OFF HEATING ELEMENTS

NO

IGNITION OFF?

YES

END

FIG. 15
FIG. 21

SET BLOCKED THRESHOLD LEVEL

MEASURE OPERATIONAL PARAMETER

NO

OPERATIONAL PARAMETER EXCEEDS BLOCKED THRESHOLD LEVEL?

USE FIRST OPERATING MODE

YES

USE SECOND OPERATING MODE