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(54) **ELECTRICAL APPLIANCE ENERGY CONSUMPTION CONTROL METHODS AND ELECTRICAL ENERGY CONSUMPTION SYSTEMS**

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See application file for complete search history.

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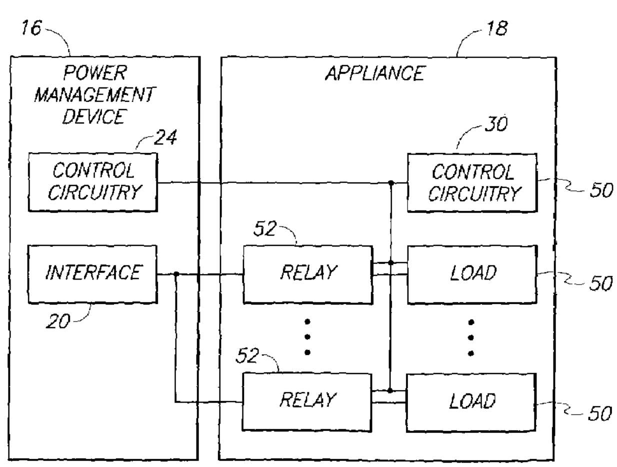
(57) **ABSTRACT**

Electrical appliance energy consumption control methods and electrical energy consumption systems are described. In one aspect, an electrical appliance energy consumption control method includes providing an electrical appliance coupled with a power distribution system, receiving electrical energy within the appliance from the power distribution system, consuming the received electrical energy using a plurality of loads of the appliance, monitoring electrical energy of the power distribution system, and adjusting an amount of consumption of the received electrical energy via one of the loads of the appliance from an initial level of consumption to an other level of consumption different than the initial level of consumption responsive to the monitoring.

104 Claims, 6 Drawing Sheets



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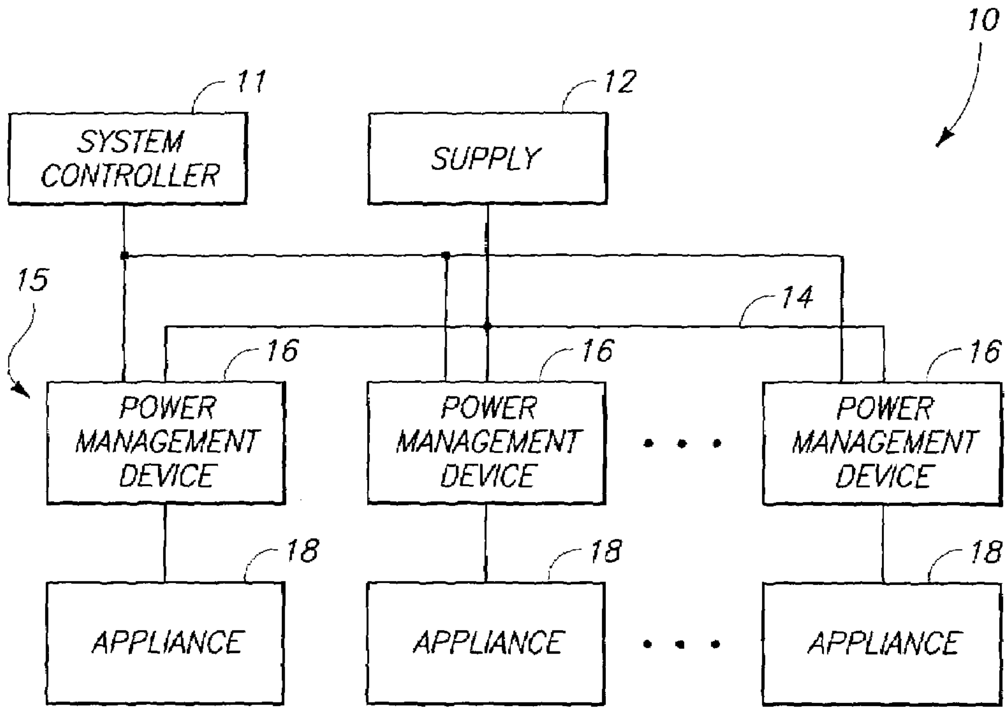
10
11
SYSTEM CONTROLLER
12
SUPPLY
15
14
16
POWER MANAGEMENT DEVICE
16
POWER MANAGEMENT DEVICE
16
POWER MANAGEMENT DEVICE
18
APPLIANCE
18
APPLIANCE
18
APPLIANCE

FIG. 1

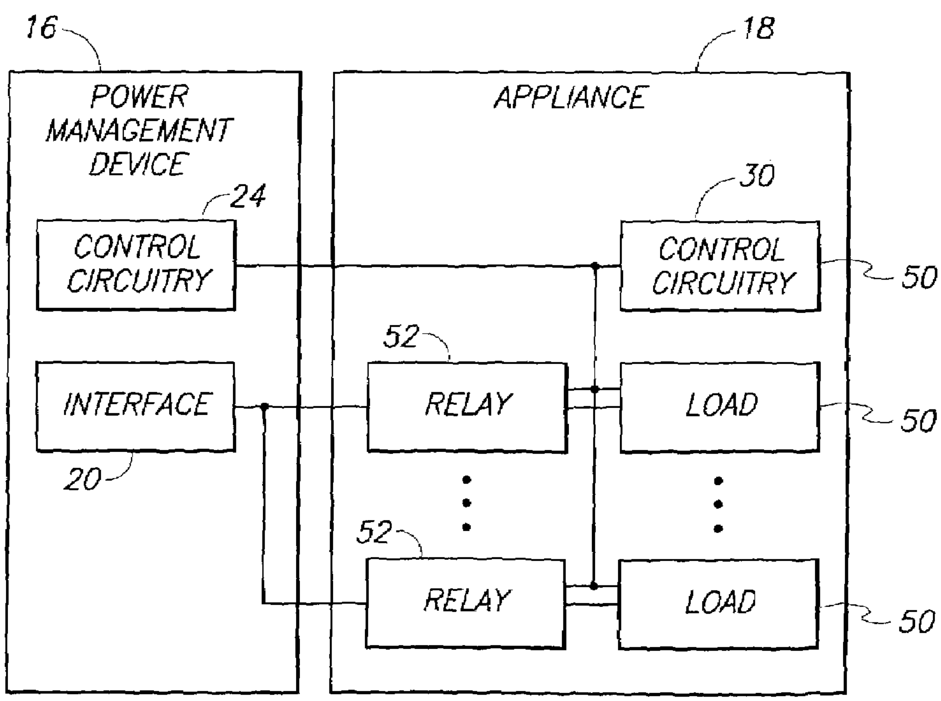
16
POWER MANAGEMENT DEVICE
24
CONTROL CIRCUITRY
INTERFACE
20
18
APPLIANCE
30
CONTROL CIRCUITRY
50
52
RELAY
LOAD
50
52
RELAY
LOAD
50

FIG. 2

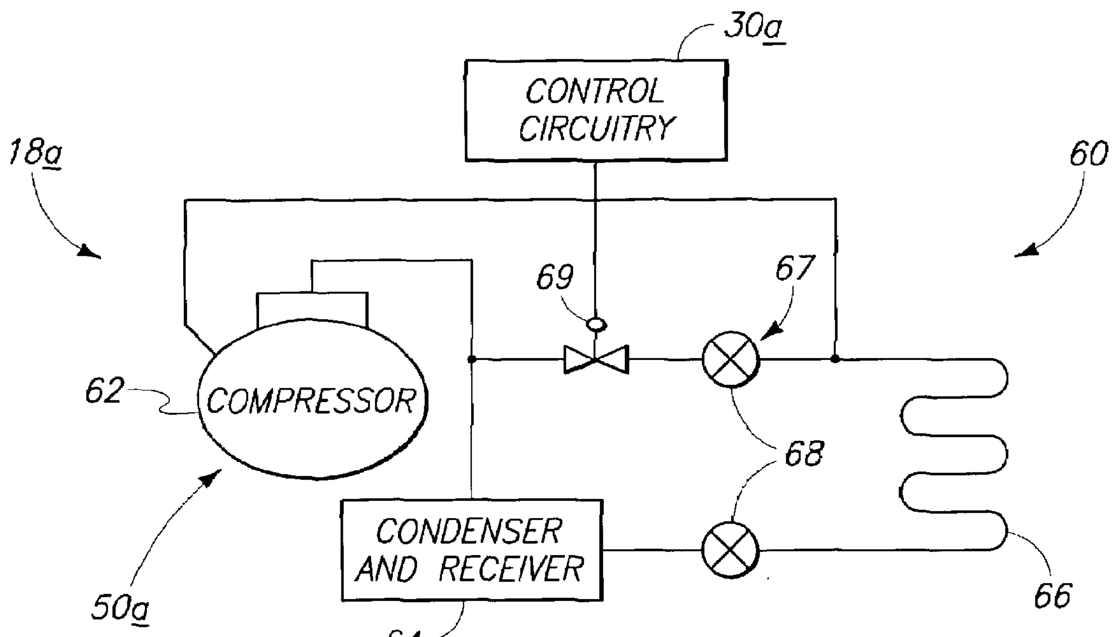
30a
CONTROL CIRCUITRY
18a
60
69
67
62
COMPRESSOR
68
CONDENSER AND RECEIVER
50a
64
66

FIG. 3

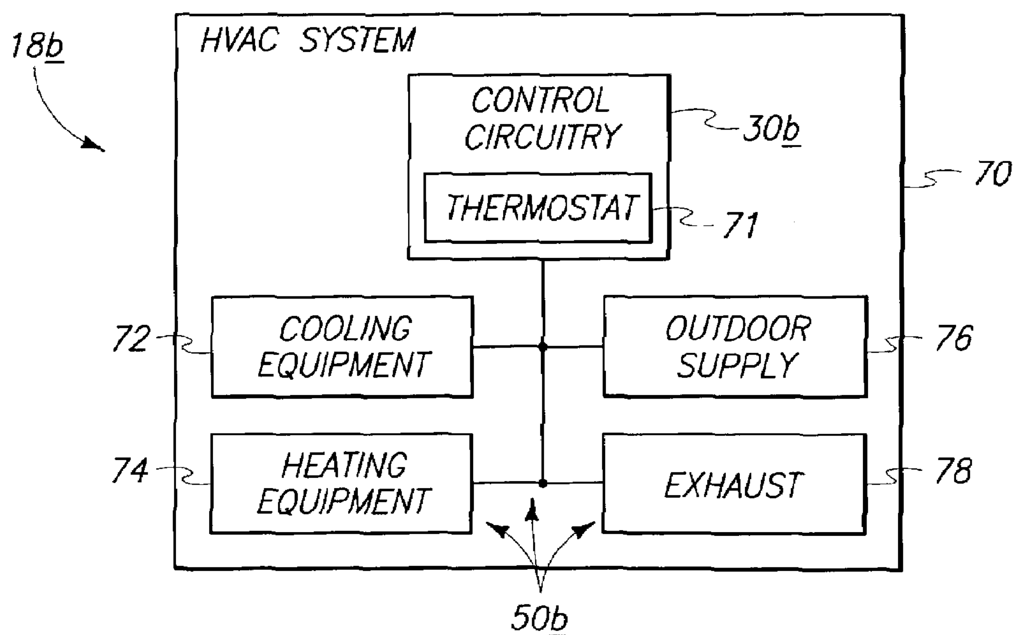
18b
HVAC SYSTEM
CONTROL CIRCUITRY
30b
70
THERMOSTAT
71
72
COOLING EQUIPMENT
OUTDOOR SUPPLY
76
74
HEATING EQUIPMENT
EXHAUST
78
50b

FIG. 4

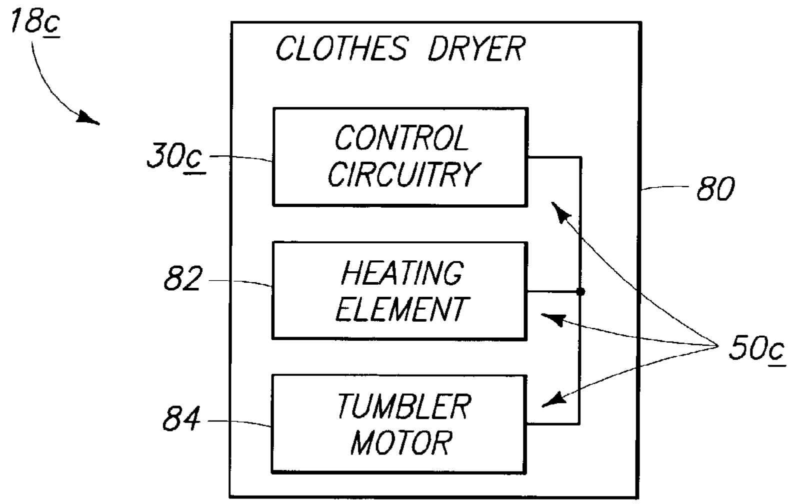
18c
CLOTHES DRYER
CONTROL CIRCUITRY
30c
HEATING ELEMENT
82
TUMBLER MOTOR
84
80
50c

Fig 5

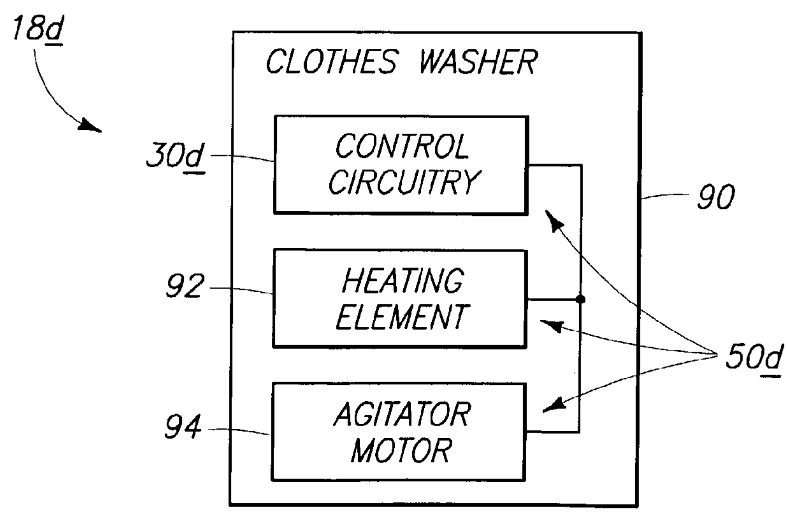
18d
CLOTHES WASHER
CONTROL CIRCUITRY
30d
HEATING ELEMENT
92
AGITATOR MOTOR
94
90
50d

Fig 6

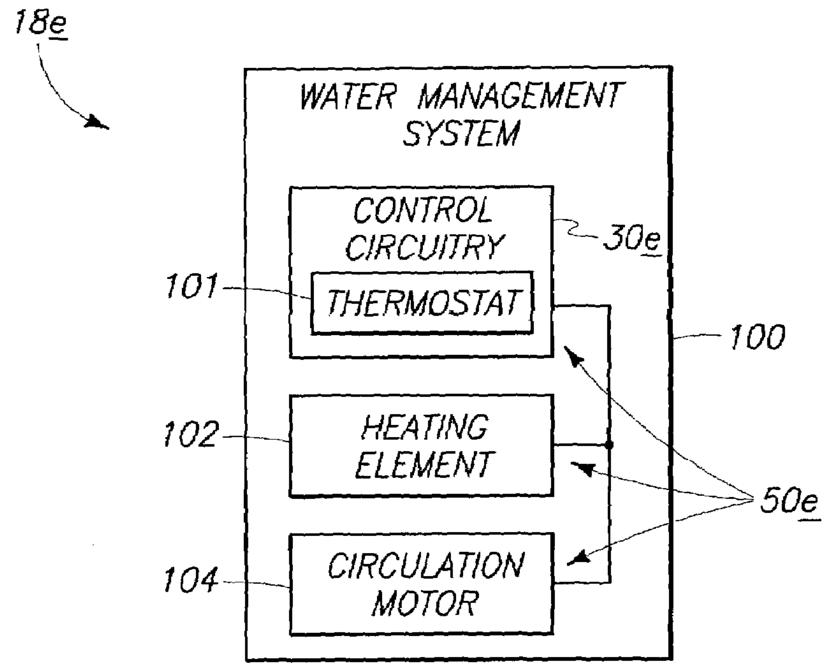
18e
WATER MANAGEMENT SYSTEM
CONTROL CIRCUITRY
30e
101
THERMOSTAT
100
102
HEATING ELEMENT
50e
104
CIRCULATION MOTOR

Fig 7

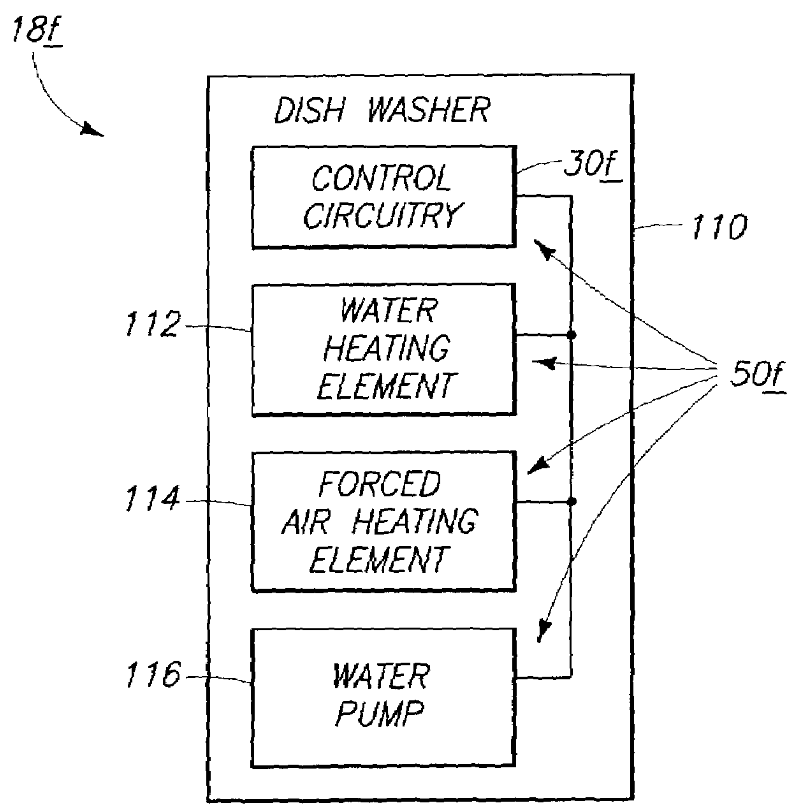
18f
DISH WASHER
CONTROL CIRCUITRY
30f
110
112
WATER HEATING ELEMENT
50f
114
FORCED AIR HEATING ELEMENT
116
WATER PUMP

Fig 8

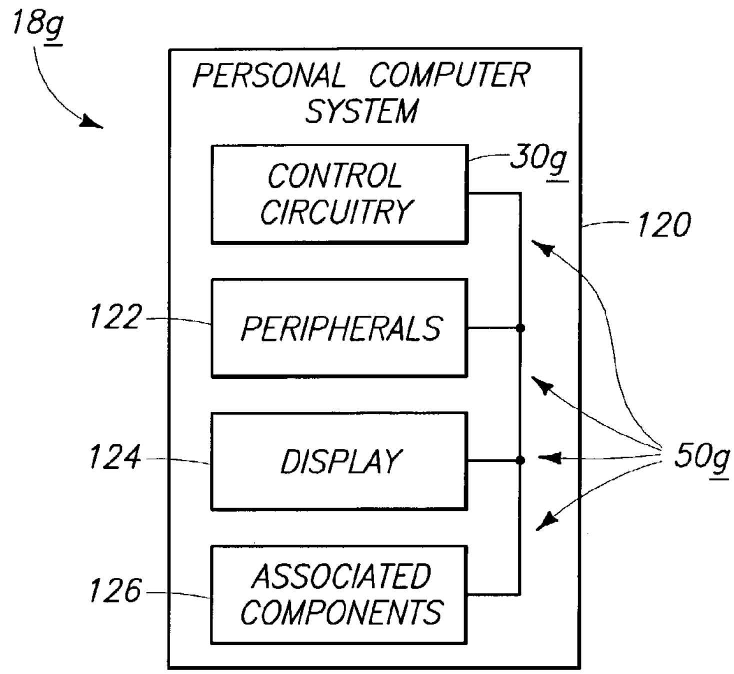
18g
PERSONAL COMPUTER SYSTEM
CONTROL CIRCUITRY
30g
120
122
PERIPHERALS
124
DISPLAY
50g
126
ASSOCIATED COMPONENTS

FIG 9

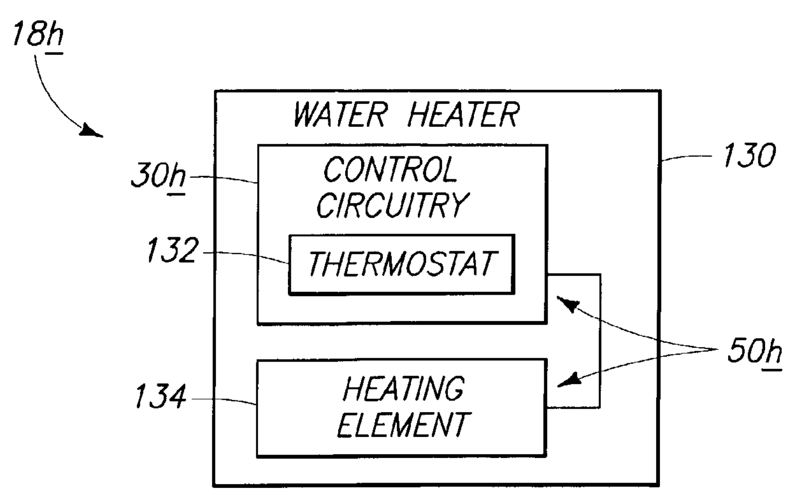
18h
WATER HEATER
30h
CONTROL CIRCUITRY
130
132
THERMOSTAT
50h
134
HEATING ELEMENT

FIG 10

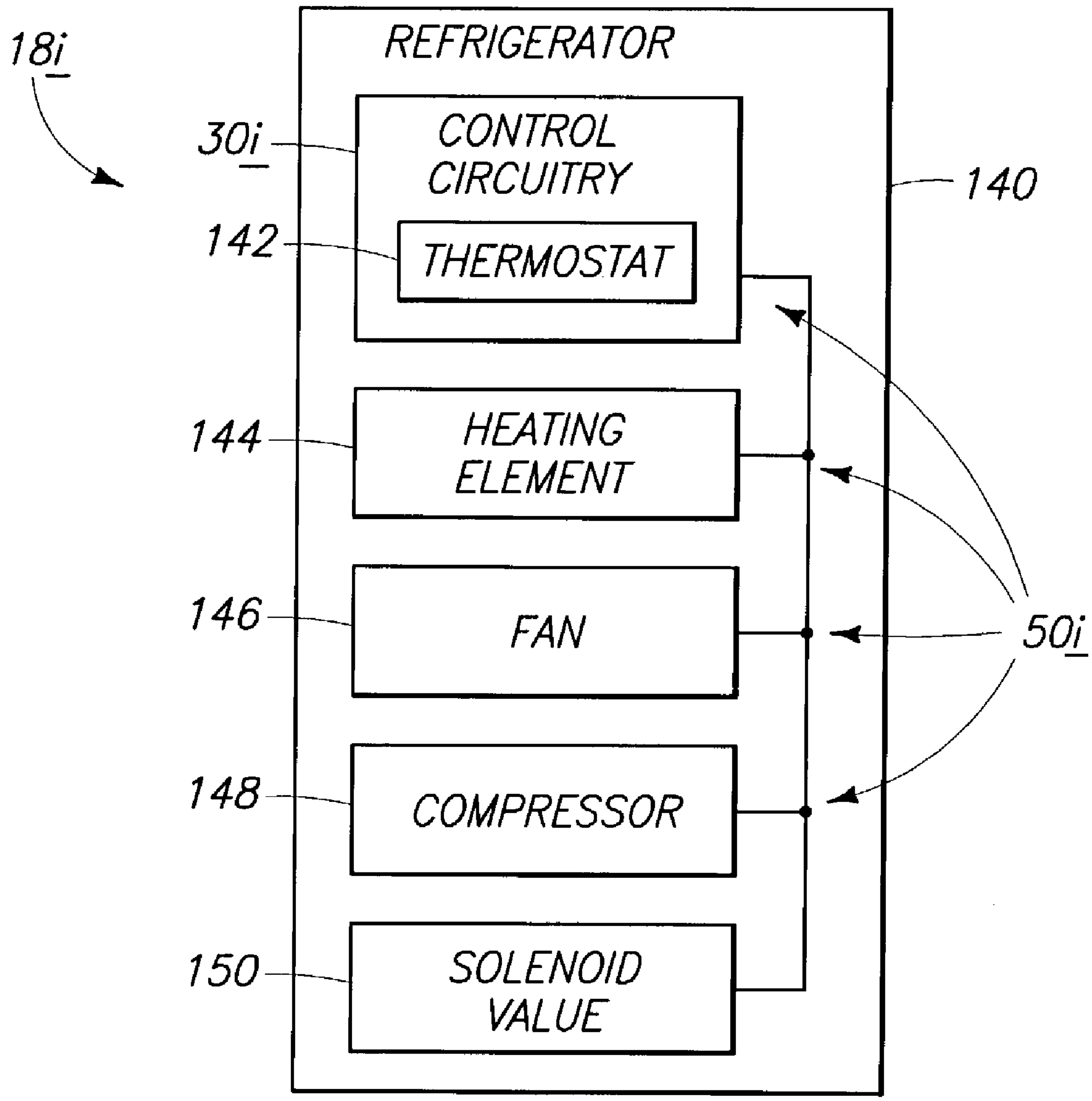
18i
REFRIGERATOR
30i
CONTROL CIRCUITRY
142
THERMOSTAT
140
144
HEATING ELEMENT
146
FAN
50i
148
COMPRESSOR
150
SOLENOID VALUE

FIG. 11

ELECTRICAL APPLIANCE ENERGY CONSUMPTION CONTROL METHODS AND ELECTRICAL ENERGY CONSUMPTION SYSTEMS

STATEMENT OF GOVERNMENT RIGHTS

This invention was made with Government support under contract DE-AC0676RLO1830 awarded by the U.S. Department of Energy. The Government has certain rights in the invention.

TECHNICAL FIELD

This invention relates to electrical appliance energy consumption control methods and electrical energy consumption systems.

BACKGROUND OF THE INVENTION

Consumption of and reliance upon electrical energy is increasing. Usage of electrical energy is ubiquitous in almost every aspect of life. Businesses, entertainment, communications, etc. are heavily dependent upon electrical energy for fundamental operation. Power distribution systems or grids provide electrical energy to households, businesses, manufacturing facilities, hospitals, etc. Such systems are typically reliable, however, numerous systems employ backup electrical supplies in case of failure of the power distribution system being utilized.

Some electrical power distribution systems are ever-changing dynamic systems and operations are often concerned with balancing generation with load. Frequency of the voltage of the electrical energy may be used as an indicator of variances between generation of electrical energy and usage of electrical energy by loads coupled with the electrical power distribution system. For example, when demand exceeds generation, the frequency of the electrical energy on the electrical power distribution system may drop, and conversely, when there is excess electrical energy available, the frequency increases. Over a given 24 hour period, it is desired to balance energy surplus and deficit so the average frequency is 60 Hz, or other desired frequency.

Typically, control of the state of the electrical power distribution system is implemented by controlling operations of generators coupled with the system. For example, at times of increased demand, the output of generators may be increased and/or other generators may be brought on-line to assist with supplying the electrical energy. In addition, spinning reserves may be utilized to accommodate unexpected significant fluctuations in demand for electrical energy. Provision of spinning reserves is costly, and much of the time, not used.

Some electrical power distribution approaches have been designed to curtail peak loads through the utilization of Demand Side Management (DSM). DSM techniques include direct load control wherein a utility has the ability to curtail specific loads as conditions warrant. In these arrangements, a utility may broadcast a control signal to specific loads when curtailment is desired (e.g., during peak usage periods).

Other electrical power distribution approaches attempt to stabilize bulk-power transmission corridors using external Flexible AC Transmission System (FACTS) devices to improve dynamic performance of transmission systems. FACTS devices, such as Static-Var Compensation (SVC) and Thyristor-Controlled Series Capacitors (TSCSs), are designed to provide stability enhancements allowing transmission facilities to be loaded to levels approaching their ultimate thermal capacity. These devices may supply reactive power to support voltage or provide modulation to damp electromechanical oscillations.

Utilities may use other devices at distribution points (e.g., substations and/or switchyards) to manage electrical power distribution operations. Exemplary management devices include underfrequency and undervoltage relays. These devices may "black out" entire neighborhoods when a grid is in trouble allowing the grid to recover before power is reapplied to the blacked out customers.

Aspects of the present invention provide improved apparatus and methods for supplying electrical energy.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention are described below with reference to the following accompanying drawings.

FIG. **1** is a functional block diagram of an electrical power distribution system according to one embodiment.

FIG. **2** is a functional block diagram illustrating a power management device and an appliance according to one embodiment.

FIG. **3** is a functional block diagram of a temperature management system according to one embodiment.

FIG. **4** is a functional block diagram of an HVAC system according to one embodiment.

FIG. **5** is a functional block diagram of a clothes dryer according to one embodiment.

FIG. **6** is a functional block diagram of a clothes washer according to one embodiment.

FIG. **7** is a functional block diagram of a water management system according to one embodiment.

FIG. **8** is a functional block diagram of a dish washer according to one embodiment.

FIG. **9** is a functional block diagram of a personal computer system according to one embodiment.

FIG. **10** is a functional block diagram of a water heater according to one embodiment.

FIG. **11** is a functional block diagram of a refrigerator according to one embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

According to one aspect of the invention, an electrical appliance energy consumption control method includes providing an electrical appliance coupled with a power distribution system, receiving electrical energy within the appliance from the power distribution system, consuming the received electrical energy using a plurality of loads of the appliance, monitoring electrical energy of the power distribution system, and adjusting an amount of consumption of the received electrical energy via one of the loads of the appliance from an initial level of consumption to an other level of consumption different than the initial level of consumption responsive to the monitoring.

According to another aspect of the invention, an electrical appliance energy consumption control method comprises providing an electrical appliance coupled with a power distribution system, the appliance comprising a plurality of loads, receiving electrical energy within the appliance from the power distribution system, operating the appliance at a normal mode of operation wherein one of the loads consumes a first amount of electrical energy, monitoring an electrical characteristic of electrical energy of the power distribution system, and responsive to the monitoring, operating the appliance at an other mode of operation wherein the one of the loads consumes a second amount of electrical energy different than the first amount of electrical energy.

According to another aspect of the invention, an electrical energy consumption system comprises a power interface configured to receive electrical energy of the power distribution system, a plurality of loads coupled with the power interface and configured to consume the received electrical energy, and control circuitry configured to monitor an electrical characteristic of the electrical energy of the power distribution system and to vary an amount of consumption of the received electrical energy via one of the loads responsive to the monitoring.

Additional aspects are described herein. For example, additional aspects relate to compressor systems, HVAC systems, clothes dryers, clothes washers, water management systems, dish washers, personal computer systems (or other devices having energy saving modes of operation), water heaters, refrigerators, and any other appliance configuration configured to consume electrical energy during operation.

Referring to FIG. **1**, an electrical power distribution system **10** is shown arranged according to one exemplary illustrative embodiment. System **10** comprises any appropriate electrical energy delivery system configured to deliver residential, commercial, industrial, or other electrical energy from a supply to customers or consumers. The depicted exemplary system **10** comprises a system controller **11**, an electrical energy supply **12**, a distribution grid **14**, and an exemplary power management system **15** comprising a plurality of power management devices **16** and/or appliances **18**. A plurality of electrical appliances **18** are depicted coupled with the electrical power distribution system **10** and are configured to consume electrical energy provided from supply **12**. In some embodiments, appliances **18** may be considered to be a part of system **10** (e.g., in configurations wherein power management operations are implemented using associated control circuitry of the appliances as described in exemplary embodiments below).

System controller **11** is configured as control circuitry to monitor and manage operations of system **10** in some embodiments. System controller **11** may comprise a microprocessor in one embodiment to implement exemplary monitoring and control aspects of the power management operations described herein. System controller **11** may be referred to as a centralized controller in one embodiment and for example operated by supply **12** or at some location distant from consumers. In one arrangement, system controller **11** is configured to monitor electrical energy distributed within system **10** and issue appropriate control signals to power management devices **16** and/or appliances **18** (e.g., via networked, wired or wireless communications) to implement power management operations described herein. Implementation of power management operations by system controller **11** configured in the above-identified centralized embodiment may be referred to as centralized operations.

Implementation of power management operations at customer locations (e.g., residential, commercial, industrial, etc.) may be referred to as passive operations. For example, power management devices **16** and/or appliances **18** may implement some or all of the power management operations (e.g., monitoring, control) at the customer locations with or without a centralized system controller **11**. In other embodiments, system controller **11** may comprise a customer located device to provide passive operations (e.g., mounted locally to provide, monitor and/or control passive operations of devices **16** and/or appliances **18** at the customer location). Accordingly, in at least some exemplary embodiments, system controller **11** provides centralized or passive power management operations described herein. In some embodiments and as mentioned above, controller **11** may be omitted and power management operations may be implemented within devices **16** and/or appliances **18**.

Supply **12** is configured to provide electrical energy for consumption by appliances **18**. Supply **12** may be arranged as one or more generator or other construction configured to supply electrical energy. Generators may be individually taken on-line or off-line, or the output thereof may be adjusted, according to the usage of the electrical energy. In one exemplary implementation, supply **12** is arranged to provide alternating current electrical energy at a system frequency of 60 Hz. System frequency is the frequency of system voltage.

Distribution grid **14** operates to conduct the electrical energy from the supply **12** to appropriate destinations for consumption. In one embodiment, distribution grid **14** may comprise a plurality of different voltage distribution lines and transformers configured to conduct the electrical energy over substantial distances between distant geographical locations. Distribution grid **14** may provide electrical energy at exemplary voltages of 120/240 VAC (residential), 120/208 VAC (commercial), 277/480 VAC (industrial) or other appropriate voltages for usage by customer appliances **18** in one example.

Power management devices **16** are configured to selectively apply electrical energy from supply **12** to respective appliances **18** as described below. In the exemplary depicted implementation, all of the illustrated appliances **18** have associated power management devices **16**. In other configurations, only some of the appliances **18** may have associated power management devices **16**. In other arrangements, a given device **16** may be configured to control power management operations of a plurality of appliances **18**.

Power management operations may be implemented in variety of configurations. For example, in the centralized arrangement, system controller **11** comprises control circuitry configured to monitor electrical energy of system **10** and issue control signals to devices **16** and/or appliances **18** to control the application of electrical energy to appliances **18**. In passive arrangements, system controller **11** may be omitted, and adjustment of the supply of electrical energy may be implemented by individual devices **16** responsive to internal monitoring by devices **16** of electrical energy of system **10**. Some embodiments of system **11** may include centralized and passive power management operations. In the described exemplary embodiments, power management operations include monitoring of electrical energy from supply **12** and adjusting (e.g., reducing) an amount of electrical energy consumed by respective appliances.

In at least one embodiment, system controller **11**, power management devices **16**, and/or appliances **18** are configured to monitor at least one characteristic of the electrical energy provided from supply **12** and control a mode of operation of one or more associated appliance load coupled therewith. In one embodiment, system frequency of the electrical energy is monitored and the amount of electrical energy consumed by a respective appliance **18** may be adjusted responsive to the monitoring. For example, in one operational implementation, power management devices **16** may reduce an amount of electrical energy supplied to respective appliances **18** responsive to detection of a drop in system frequency of the electrical energy provided by supply **12**. Monitoring operations and control operations may be split between controller **11**, respective device **16**, and/or respective appliance **18**. One or more of controller **11**, device **16**, or control circuitry of appliance **18** may be omitted and the existing control circuitry provides monitoring and control operations. In some arrangements, both the monitoring and control operations may be provided by one of controller **11**, respective device **16**, or respective appliance **18**.

In the exemplary illustrated embodiment, system controller **11** and/or power management devices **16** are depicted separate from appliances **18**. In other possible embodiments, system controller **11** and/or power management devices **16** may be at least proximately located to the respective appliances **18**, physically positioned adjacent to or physically coupled with the respective appliances **18**, and/or embedded within the appliances **18** (e.g., providing the power management devices **16** within housings of the appliances **18**).

In one arrangement (e.g., passive arrangement), power management devices **16** are configured to monitor a condition of electrical energy of the system **10** to implement power management operations. In one embodiment, device **16** monitors the electrical energy at a node used to supply electrical energy from grid **14** to appliance **18**. The node may be implemented using a customer wall outlet or other suitable local connection for coupling the appliance **18** to the grid **14**. In one arrangement, system controller **11** may correspond to a physical customer location (e.g., residence, commercial location, industrial location, etc.) configured to interact with one or more appliance **18** of the customer location as mentioned previously. System controller **11** may monitor electrical energy supplied by supply **12** and distributed by distribution grid **14**. System controller **11** may output control signals to device(s) **16** and/or appliance(s) **18** to selectively control the operations thereof in modes of reduced power consumption responsive to the monitoring.

It is possible to implement power management operations (e.g., monitor and/or control operations) described herein (or other operations of control circuitry **24** of device **16** described below) using control circuitry of an electrical appliance **18** itself (e.g., control circuitry **30** described below) and configured to control operations with respect to the electrical appliance **18**. These implementations are exemplary and other implementations or operations are possible.

Appliances **18** may have any configuration which consumes supplied electrical energy. Appliances **18** may also be referred to as motors or utilization equipment. A plurality of power management devices **16** are arranged to control respective appliances **18**. In other embodiments, one device **16** may be implemented to control consumption of electrical energy of a plurality of appliances **18** as mentioned above.

Further exemplary details regarding electrical power distribution system **10**, power management devices **16**, and power management operations including controlling operations of appliances **18** or other loads according to some embodiments are described in a U.S. Patent Application entitled "Electrical Power Distribution Control Methods, Electrical Energy Demand Monitoring Methods, And Power Management Devices", having client docket no. B1367, listing David P. Chassin, Matt Donnelly, and Jeff Dagle as inventors, and the teachings of which are incorporated herein by reference.

Referring to FIG. **2**, additional details regarding power management device **16** and appliance **18** according to one possible embodiment are presented. The power management device **16** and associated appliance **18** may be referred to as an electrical energy consumption system.

The depicted power management device **16** includes an interface **20** and control circuitry **24**. Interface **20** is arranged to receive operational electrical energy for consumption using the respective appliance **18**. Interface **20** may be referred to as a power interface and comprise the node described above. Interface **20** may be implemented using a wall outlet adapter able to receive supplied residential, commercial, industrial, or other electrical energy in exemplary configurations. Control circuitry **24** may be embodied as a microprocessor or other appropriate control architecture.

The depicted exemplary appliance **18** comprises control circuitry **30**, a plurality of associated loads **50**, and a plurality of relays **52**. Control circuitry **30** may be implemented as a microprocessor or other appropriate control architecture and may also comprise an associated load **50**. Associated loads **50** consume electrical energy. Relays **52** selectively supply electrical energy power from grid **14** to respective loads **50**. In other configurations, a single relay **52** may supply electrical energy to a plurality of loads **50** of a given appliance **18**. Other configurations for controlling the application of electrical energy from interface **20** to load(s) **50** are possible.

Power management device **16** may be configured according to the exemplary device arrangements described in the incorporated patent application. Power management device **16** is arranged in one embodiment as a discrete device separate from the appliance **18** as mentioned above. Alternately, power management device **16** may be implemented entirely or partially using existing components of the appliance **18**. For example, functionality of control circuitry **24** may be implemented using control circuitry **30** to monitor electrical energy of power distribution system **10** and to control consumption of electrical energy by one or more of loads **50** responsive to the monitoring. As described in the incorporated patent application, a relay (or other switching device not shown in FIG. **2**) internal of device **16** may be used to adjust the amount of electrical energy consumed by appliance **18**. Control circuitry **24** and/or control circuitry **30** may be arranged to control the operations of the associated relay (not shown) of device **16**. As shown, appliance **18** may comprise associated relays **52** which may be controlled by control circuitry **24** and/or control circuitry **30**. Switching device configurations other than the described relays may be used.

In other arrangements, control circuitry **24** may provide control signals to control circuitry **30** or directly to loads **50** to control the rate of consumption of electrical energy by loads **50** without the use of relays **52** (accordingly relays **52** may be omitted). Responsive to the received control signals, control circuitry **30** may operate to control respective loads **50**, or loads **50** may internally adjust rates of consumption of the electrical energy responsive to directly receiving the control signals from circuitry **24** or **30**.

According to the specific arrangement of the appliance **18** being controlled, aspects described herein, including monitoring of electrical energy of system **10** and/or controlling the consumption of power within appliance **18**, may be implemented using circuitry internal and/or external of the appliance **18**. The discussion herein proceeds with respect to exemplary configurations wherein monitoring and control operations are implemented by control circuitry **30**. Any alternate configurations may be used to implement functions and operations described herein.

Appliances **18** comprise devices configured to consume electrical energy. Exemplary appliances **18** described below include temperature maintenance systems, HVAC systems, clothes dryers, clothes washers, water management systems (e.g., spa and/or pool), dish washers, personal computer systems, water heaters, and refrigerators. The described appliances **18** are exemplary for discussion purposes and other arrangements are possible.

As shown in the exemplary arrangement of FIG. **2**, appliances **18** may individually comprise a plurality of different associated loads **50** individually configured to consume electrical energy. For example, for a given appliance **18**, one of loads **50** may be a control load wherein processing is implemented (e.g., 3–5 Volt circuitry of control circuitry **30**) and another of the loads **50** may be a higher voltage load including exemplary motors, heating coils, etc.

Consumption of electrical energy by such appliances **18** may be adjusted by turning off (or otherwise adjusting the operation of one associated load **50** while leaving another associated load **50** powered (or otherwise unaffected). During exemplary power management operations, it may be desired adjust an amount of electrical energy applied to one of the associated loads **50** of a given appliance **18** (e.g., a high power associated load) while continuing to provide full (or otherwise unadjusted) amount of electrical energy to another of the associated loads **50** of the given appliance **18** (e.g., a low power associated load). Alternately, power may be adjusted, reduced or ceased for all associated loads all together.

Adjustment of the consumption of electrical energy by an appliance **18** may be implemented responsive to monitoring by appropriate control circuitry of electrical energy of power distribution system **10**. In one embodiment, a characteristic (e.g., system frequency) of the electrical energy is monitored. The incorporated patent application provides exemplary monitoring operations of system frequency (e.g., voltage) of electrical energy supplied by power distribution system **10**. Other characteristics of electrical energy of system **10** may be monitored in other constructions.

Responsive to the monitoring, appropriate control circuitry is configured to adjust an amount of consumption of electrical energy within at least one of the loads **50** from an initial level of consumption to an other different level of consumption. For example, as described in the incorporated application, if the system frequency of the electrical energy deviates a sufficient degree from a nominal frequency, a threshold is triggered. As described in the incorporated application, the threshold may be varied at different moments in time (e.g., responsive to power-up operations of appliance **18** at different moments in time). In one embodiment, the varying of the threshold is random.

Appropriate control circuitry may adjust an amount of consumption of electrical energy (e.g., via one of loads **50**) from an initial level to an other different level (e.g., reduced consumption mode) responsive to the threshold being triggered. Thereafter, the control circuitry continues to monitor the electrical energy. If the frequency returns to a desired range, the control circuitry may return the operation of the appliance **18** and load(s) **50** to a normal mode of operation (e.g., a mode wherein an increased amount of electrical energy is consumed). As described in the incorporated patent application, a variable length of time may be used to return the consumption to the initial level and the variable length of time may be randomly generated in at least one embodiment.

Accordingly, the appropriate control circuitry may control operation of the adjusted load **50** for a period of time at the adjusted level of electrical energy consumption. During the adjustment, the control circuitry may maintain the level of consumption of another load **50** of the appliance **18** at a normal level of consumption.

Some arrangements of power management device **16** permit override functionality. For example, the appropriate control circuitry may have associated user interface circuitry (not shown) usable by a user to disable power management operations via an override indication (e.g., hit a key of the user interface circuitry). Responsive to the reception of the override indication, the control circuitry may return the mode of operation of the affected load **50** to a normal consumption mode (e.g., wherein an increased amount of electrical energy is consumed compared with the level of consumption initiated during the power management operations).

Referring to FIGS. **3**–**11**, exemplary configurations of appliances **18**_a_–**18**_i_ are shown. The figures depict exemplary appliances configured to implement power management operations. The illustrated appliances **18**_a_–**18**_i_ include respective control circuits **30**_a_–**30**_i_. The control circuits **30**_a_–**30**_i_ may interface with system controller **11** and/or control circuitry **24** of power management device **16** (not shown in FIGS. **3**–**11**) to implement power management operations in one embodiment. In other embodiments, power management operations may be implemented solely internally of the appliances **18**_a_–**18**_i_ using the respective control circuits **30**_a_–**30**_i_. The described appliances **18**_a_–**18**_i_ are for illustration and other arrangements of the appliances are possible.

Referring specifically to FIG. **3**, appliance **18**_a_ arranged as a compressor system is depicted. The depicted compressor system is arranged as a temperature management system **60** although other configurations which use a compressor are possible. An exemplary temperature management system **60** may include an air conditioner, heat pump, or other arrangement implementing load control strategies using electrically driven vapor compression cycles for heating, venting, air-conditioning, refrigeration or other applications. The exemplary system **60** includes a compressor **62**, condenser and receiver **64**, evaporator **66**, short circuit path **67**, expansion valves **68** and solenoid valve **69**. Control circuitry **30**_a_ and compressor **62** comprise associated loads **50**_a_ of the depicted system **60**. Compressor **62** is arranged to compress a fluid within the system, condenser **64** is configured to condense the fluid, and evaporator **66** is configured to evaporate the fluid in one embodiment.

In one embodiment, power management operations of system **60** use hot-gas bypass techniques to temporarily unload compressor **62**. Control circuitry **30**_a_ may selectively control solenoid valve **69** to open short circuit path **69** and couple the suction line with the hot-gas line and bypass compressor **62** and evaporator **66** in a vapor compression cycle. This technique provides capacity control and reduces a starting and stopping duty cycle of compressor **62**. The operations may be implemented without unduly burdening an electric motor (not shown) of compressor **62** with potentially damaging transients. In some embodiments, the short circuiting may be implemented for a few seconds and would most likely not be noticed by a consumer.

Referring to FIG. **4**, appliance **18**_b_ arranged as an HVAC system **70** is shown. HVAC system **70** is configured in one embodiment to adjust a temperature of an associated area, such as an enclosed, controlled area (e.g., building, house, etc.). An exemplary HVAC system **70** may include control circuitry **30**_b_, a thermostat **71** (e.g., embodied within control circuitry **30**_b_), cooling equipment **72** (e.g., air conditioning assembly, heat pump, etc.), heating equipment **74** (e.g., forced air, oil, steam, heat pump, etc.), outdoor supply **76** (e.g., fan, dampers), and exhaust **78** (e.g., fan, dampers). Control circuitry **30***b*, cooling equipment **72**, heating equipment **74**, outdoor supply **76** and exhaust **78** may comprise associated loads **50***b* of system **80**.

In one embodiment, power management operations of system **70** and implemented by control circuitry **30***b* include adjusting a set point of thermostat **71**. For example, during cooling operations, the thermostat set point may be temporarily raised, and for heating operations, the thermostat set point may be temporarily lowered. In other exemplary power management operations, control circuitry **30***b* may directly disable or provide other control of cooling and/or heating equipment **72**, **74**.

Additional power management operations include controlling fans or dampers of outdoor supply **76** or exhaust **78** using control circuitry **30***b* to provide desired configurations during operation in modes of reduced power consumption. The fans and dampers can be provided by circuitry **30***b* into desired configurations (fans on or off and/or dampers open or closed) with respect to building supply and exhaust operations. For configurations wherein a heat pump (not shown) is implemented within cooling and/or heating equipment **72**, **74**, control circuitry **30***b* may temporarily disable or cancel a defrost operation of the heat pump during power management operations. If disabled or canceled, control circuitry **30***b* may reschedule the defrost operation to another moment in time (e.g., in configurations wherein defrost operations are timer controlled).

Referring to FIG. **5**, appliance **18***c* arranged as a clothes dryer **80** is shown. An exemplary clothes dryer **80** may include control circuitry **30***c*, a heating element **82**, and a tumbler motor **84**. Heating element **82** is configured in one embodiment to heat an associated compartment (not shown) of clothes dryer **80** configured to receive and dry clothes. Tumbler motor **84** is configured to spin clothes within the associated compartment during drying operations. Control circuitry **30***c*, heating element **82** and tumbler motor **84** comprise exemplary associated loads **50***c* of clothes dryer **80** in the depicted embodiment.

In one configuration, power management operations of clothes dryer **80** include reducing or ceasing the supply of electrical energy to heating element **82** (e.g., reducing an amount of current supplied to heating element **82**) and/or tumbler motor **84**. It may be desired to maintain tumbler motor **84** in an operative mode during an implementation of power management operations with respect to heating element **82**.

Referring to FIG. **6**, appliance **18***d* arranged as a clothes washer **90** is shown. An exemplary clothes washer **90** may include control circuitry **30***d*, a heating element **92**, and an agitator motor **94**. Heating element **92** is configured to heat water used in an associated compartment (not shown) of clothes washer **90** configured to receive and wash clothes. Agitator motor **94** is configured to oscillate between different rotational directions or otherwise agitate clothes within the associated compartment during wash and/or rinse operations. Control circuitry **30***d*, heating element **92** and agitator motor **94** comprise associated loads **50***d* of clothes washer **90** in the depicted embodiment.

In one configuration, power management operations of clothes washer **90** include reducing or ceasing the supply of electrical energy to heating element **92** to reduce internal temperatures of water in the associated compartment and/or agitator motor **94** to reduce motion of the motor **94**. The reduction in power by controlling heating element **92** may be linear and accordingly the benefits may be directly proportional to the reduction in the water temperature. The reduction in power to agitator motor **94** may be proportional to a product of angular acceleration, mass and angular velocity. A slowing down of agitator motion of motor **94** could affect both a reduction in acceleration as the motor reverses its motion as well as angular velocity. In other embodiments, it may be desired to maintain agitator motor **94** in an operative mode during an implementation of power management operations with respect to heating element **92**.

Referring to FIG. **7**, appliance **18***e* arranged as a water management system **100** is shown. Water management system **100** is configured to provide heating, circulation and/or filtering of water within a water reservoir (not shown in FIG. **7**) of a spa (hot tub), swimming pool, or other configuration in exemplary implementations. The illustrated configuration of water management system **100** includes control circuitry **30***e* (embodying a thermostat **101** in the depicted exemplary configuration), a heating element **102**, and a circulation motor **104** (e.g., circulation and/or filter pump). Control circuitry **30***e*, heating element **102** and circulation motor **104** comprise associated loads **50***e* of system **100** in an exemplary configuration.

According to an illustrative embodiment, power management operations of system **100** implemented by control circuitry **30***e* include adjusting a set point of thermostat **101**. For example, the thermostat set point may be temporarily lowered. In other exemplary power management operations, control circuitry **30***e* may directly disable or provide other control of heating element **102** and/or circulation motor **104**. In specific exemplary arrangements, control circuitry **30***e* may adjust an amount of current provided to heating element **102**, or control the angular velocity of motor **104** to adjust (e.g., reduce) water circulation operations of the spa, pool or other water reservoir during operation in modes of reduced power consumption. The power management operations are temporary in the described example, and accordingly, the operations are typically transparent to a user.

Referring to FIG. **8**, appliance **18***f* arranged as an exemplary dish washer **110** is illustrated. Dish washer **110** includes control circuitry **30***f*, a water heating element **112**, a forced air heating element **114**, and a water pump **116** in but one embodiment. Dish washer **110** may additionally include a compartment (not shown) configured to receive to dishes. Water heating element **112** may adjust a temperature of water used to wash dishes using dish washer **110** in one embodiment. Forced air heating element **114** adjusts a temperature of air used to dry the dishes in one implementation. Water pump **116** may spray water on the dishes during a cleaning and/or rinsing cycle to provide a dish cleaning action and/or rinsing action. Control circuitry **30***f*, heating elements **112**, **114**, and water pump **116** may comprise associated loads **50***f* of dish washer **110**.

Exemplary power management operations of dish washer **110** implemented by control circuitry **30***f* in one embodiment include controlling the water heater **112** to reduce a water temperature boost cycle during wash operations and/or reduce air temperature by forced air heater **114** during rinsing/drying operations. Reduction of water temperature provides corresponding linear reductions in electrical power consumption. Control circuitry **30***f* may also control operations of water pump **116** (e.g., reduce the operational speed of pump **116**) during modes of reduced power consumption.

Referring to FIG. **9**, appliance **18***g* arranged as an exemplary home and office system **120** is illustrated. System **120** includes at least one component or device configured to selectively operate in an energy saving mode (e.g., in accordance with Energy Star™) wherein a reduced amount of electrical energy is consumed by the device or component. Exemplary devices or components may enter such an energy saving mode without power management operations discussed herein in one embodiment. Other arrangements of system **120** apart from the exemplary depicted home and office system and which include at least one device or component configured to operate in an energy saving mode are possible.

As shown, system **120** comprises a personal computer system in the depicted example and includes a plurality of components including control circuitry **30***g* (e.g., personal computer microprocessor), peripherals **122** (e.g., laser printer), a display **124** (e.g., CRT), and other associated components **126** (e.g., fans, disk drives, etc.) which comprise associated loads **50***g* of appliance **18***g* in the depicted example.

At least some of loads **50***g* are configured to independently or dependently operate in a plurality of respective operational modes, including an energy saving mode wherein a reduced amount of electrical energy is consumed, in the described example. Control circuitry **30***g* is configured to implement exemplary power management operations including selectively providing individual ones or all loads **50***g* into the respective energy saving modes of operation (e.g., in addition to any other programming or criteria configured to provide such devices or components into the respective energy saving modes). For example, control circuitry **30***g* may enter an energy saving mode of operation having reduced clock speed. A peripheral **122** embodied as a laser printer may enter an energy saving mode wherein a laser printer heating element (e.g., toner fusing assembly) is configured to consume a reduced amount of electrical energy. Display **124** may enter an energy saving mode wherein a cathode ray tube is configured to consume a reduced amount of electrical energy. Control circuitry **30***g* may control any associated device or component of system **120** to enter an energy saving mode (if provided for the device or component) according to exemplary described aspects.

Referring to FIG. **10**, appliance **18***h* configured as an exemplary water heater **130** is shown. Water heater **130** includes control circuitry **30***h* (embodying a thermostat **132** in the illustrated configuration) and a heating element **134**. Heating element **134** is configured to heat water in an associated reservoir (not shown) to a desired temperature in the depicted configuration. Control circuitry **30***h* and heating element **134** comprise loads **50***h* of water heater **130** in one embodiment.

According to an illustrative embodiment, power management operations of system **130** and implemented by control circuitry **30***h* include adjusting a set point of thermostat **132**. For example, the thermostat set point may be temporarily lowered (e.g., for a period of tens of seconds, or a few minutes in some examples). In other exemplary power management operations, control circuitry **30***h* may directly disable or provide other control of heating element **134**.

According to additional exemplary aspects, a set point of any of the thermostats disclosed herein of the various appliances **18***a*–**18***g* may be assigned to one of a plurality of possible power management set points according to a monitored condition of electrical energy of system **10**. For example, a scale of set points may be used according to the condition of the electrical energy (e.g., the temperature set point may be decreased at predefined decrements (1–10 degrees for example) corresponding to the system frequency of the electrical energy deviating respective predetermined amounts (e.g., 10 mHz) from the nominal frequency. In accordance with the described example, the magnitude of adjustment of the thermostat set point increases as the deviation of the system frequency from the nominal frequency increases.

Referring to FIG. **11**, appliance **18***i* configured as an exemplary refrigerator **140** is shown. The illustrated refrigerator **140** includes control circuitry **30***i* (embodying a thermostat **142**), a heating element **144**, a fan **146**, a compressor **148**, and a solenoid valve **150** in the depicted embodiment. Control circuitry **30***i*, heater **144**, fan **146**, and compressor **148** comprise exemplary loads **50***i* in the depicted example.

First exemplary power management operations of control circuitry **30***i* include adjustment of a temperature set point of thermostat **142**. It may be desired in at least one embodiment to set a relatively short duration of any temperature adjustment during power arrangement operations. Another possible power management operation provides temporary disablement of defrost operations of heating element **144** (e.g., coupled with unillustrated coils of refrigerator **140**), or adjusting a time of the defrost operations controlled by control circuitry **30***i*. In another arrangement, heating element **144** may be used to provide anti-sweat operations (e.g., appropriately positioned adjacent an exterior portion of an unillustrated cabinet of refrigerator **140**—for example adjacent to a door) and power management operations may include temporary disablement of the anti-sweat operations or otherwise adjusting such operations to occur at another moment in time wherein power management operations are not being implemented. Additional exemplary power management operations include disablement of interior air circulation operations implemented by fan **146** and/or controlling operations of compressor **148** (e.g., including temporarily disabling or reducing the speed of compressor **148**). Additional aspects include implementing a hot gas bypass operation of compressor **148** using solenoid valve **150** and as described in further detail above in one example. One other embodiment provides a multi-stage refrigerator **140** having a plurality of cooling stages and a power management operation includes controlling the refrigerator **140** to operate at less than the available number of cooling stages thereby reducing the amount of energy consumed by the appliance.

In compliance with the statute, the invention has been described in language more or less specific as to structural and methodical features. It is to be understood, however, that the invention is not limited to the specific features shown and described, since the means herein disclosed comprise preferred forms of putting the invention into effect. The invention is, therefore, claimed in any of its forms, or modifications within the proper scope of the appended claims appropriately interpreted in accordance with the doctrine of equivalents.

What is claimed is:

1. An electrical appliance energy consumption control method comprising:

providing an electrical appliance coupled with a power distribution system;

receiving electrical energy within the appliance from the power distribution system;

consuming the received electrical energy using a plurality of loads of the appliance;

monitoring electrical energy of the power distribution system; and

adjusting an amount of consumption of the received electrical energy via one of the loads of the appliance from an initial level of consumption to an other level of consumption different than the initial level of consumption responsive to the monitoring.

2. The method of claim **1** further comprising:

operating the one of the loads at the other level of consumption for a period of time; and maintaining an amount of consumption of the received electrical energy via an other of the loads of the appliance during at least a portion of the period of time.

3. The method of claim **1** wherein the monitoring comprises monitoring an electrical characteristic of the electrical energy of the power distribution system.

4. The method of claim **3** wherein the adjusting comprises adjusting responsive to the electrical characteristic triggering a threshold.

5. The method of claim **4** further comprising varying the threshold at a plurality of different moments in time.

6. The method of claim **4** further comprising varying the threshold at a plurality of different moments in time corresponding to respective power-up operations of the appliance at different moments in time.

7. The method of claim **3** wherein the monitoring comprises monitoring the frequency of the electrical energy.

8. The method of claim **7** wherein the monitoring comprises monitoring frequency of the electrical energy distributed to the appliance by the power distribution system.

9. The method of claim **1** wherein the monitoring comprises monitoring using control circuitry proximately located with respect to the appliance.

10. The method of claim **9** wherein the control circuitry resides within the appliance.

11. The method of claim **9** wherein the receiving comprises receiving the electrical energy via a node of the power distribution system, and the controller monitors the electrical energy at the node.

12. The method of claim **1** wherein the adjusting comprises initial adjusting, and further comprising other adjusting the amount of consumption of the received electrical energy via the one of the loads to the initial level of consumption after the initial adjusting.

13. The method of claim **12** further comprising determining a variable length of time after the adjusting, and the other adjusting is responsive to the determining.

14. The method of claim **13** wherein the determining comprises determining a random length of time.

15. The method of claim **13** wherein the determining comprises determining the variable length of time according to a statistical distribution.

16. The method of claim **1** wherein the adjusting comprises adjusting the amount of the consumption to the other level of the consumption at a plurality of different moments in time, and further comprising operating the one of the loads at the other level of consumption for a plurality of different lengths of time at the respective different moments in time.

17. The method of claim **1** wherein the amount of the consumption during the other level of consumption is less than the amount of the consumption during the initial level of consumption.

18. The method of claim **1** wherein the one of the loads consumes substantially none of the received electrical energy during the other level of consumption.

19. The method of claim **1** wherein the adjusting comprises sending a control signal from a controller to the one of the loads.

20. The method of claim **1** further comprising:

providing an override indication after the adjusting; and

further adjusting the amount of consumption of the received electrical energy via the one of the loads to the initial level of consumption responsive to the override indication.

21. The method of claim **1** wherein the adjusting comprises adjusting the amount of consumption of the received electrical energy via a compressor of a compressor system in a hot gas bypass operation.

22. The method of claim **1** wherein the receiving comprises receiving within the appliance located at a customer location, and at least one of the monitoring and controlling comprises using control circuitry located at the customer location.

23. The method of claim **22** wherein the control circuitry comprises a system controller.

24. The method of claim **22** wherein the control circuitry comprises control circuitry of a power management device coupled with the appliance.

25. The method of claim **22** wherein the control circuitry comprises control circuitry of the appliance.

26. The method of claim **1** wherein the providing the appliance comprises providing an HVAC system.

27. The method of claim **26** wherein the adjusting comprises adjusting a temperature set point of a thermostat of the HVAC system.

28. The method of claim **26** wherein the adjusting comprises controlling cooling equipment of the HVAC system.

29. The method of claim **26** wherein the adjusting comprises controlling heating equipment of the HVAC system.

30. The method of claim **26** wherein the adjusting comprises controlling a damper of the HVAC system.

31. The method of claim **26** wherein the adjusting comprises controlling a fan of the HVAC system.

32. The method of claim **26** wherein the adjusting comprises canceling a defrost operation of a heat pump of the HVAC system.

33. The method of claim **1** wherein the providing the electrical appliance comprises providing a clothes dryer.

34. The method of claim **31** wherein the adjusting comprises adjusting the amount of consumption of the received electrical energy via one of the loads of the clothes dryer comprising a heating element.

35. The method of claim **34** wherein the adjusting comprises reducing an amount of current of the electrical energy applied to the heating element.

36. The method of claim **1** wherein the providing the electrical appliance comprises providing a clothes washer.

37. The method of claim **36** wherein the adjusting comprises adjusting the amount of consumption of the received electrical energy via the one of the loads of the clothes washer comprising a heating element.

38. The method of claim **36** wherein the adjusting comprises adjusting the amount of consumption of the received electrical energy via the one of the loads of the clothes washer comprising an agitator motor.

39. The method of claim **1** wherein the providing the electrical appliance comprises providing a water management system of one of a spa and a pool.

40. The method of claim **39** wherein the adjusting comprises adjusting a temperature set point of the water management system.

41. The method of claim **39** wherein the adjusting comprises adjusting water circulation operations of the water management system using the one of the loads comprising a water circulation motor.

42. The method of claim **39** wherein the adjusting comprises adjusting water heating operations of the water management system using the one of the loads comprising a water heating element.

43. The method of claim **1** wherein the providing the electrical appliance comprises providing a dish washer.

44. The method of claim 43 wherein the adjusting comprises adjusting water heating operations of the dishwasher using the one of the loads comprising a water heating element.

45. The method of claim 43 wherein the adjusting comprises adjusting drying operations of the dishwasher using the one of the loads comprising a forced air heating element.

46. The method of claim 43 wherein the adjusting comprises adjusting operations of one of the loads comprising a water pump.

47. The method of claim 1 wherein the providing the electrical appliance comprises providing the electrical appliance having a plurality of modes of operation including an energy saving mode of operation, and the adjusting comprises adjusting the appliance to operate in the energy saving mode.

48. The method of claim 47 wherein the electrical appliance comprises a personal computer system.

49. The method of claim 48 wherein the adjusting comprises adjusting a clock speed of control circuitry of the personal computer system.

50. The method of claim 1 wherein the providing the electrical appliance comprises providing a hot water heater.

51. The method of claim 50 wherein the adjusting comprises adjusting a temperature set point of a thermostat of the hot water heater.

52. The method of claim 50 wherein the adjusting comprises adjusting the temperature set point to one of a plurality of set points corresponding to a plurality of respective values of the electrical characteristic.

53. The method of claim 50 wherein the adjusting comprises adjusting water heating operations using the one of the loads comprising a water heating element.

54. The method of claim 1 wherein the providing the electrical appliance comprises providing a refrigerator.

55. The method of claim 54 wherein the adjusting comprises adjusting a temperature set point of a thermostat of the refrigerator.

56. The method of claim 54 wherein the adjusting comprises adjusting defrost operations of the refrigerator using the one of the loads comprising a heater configured to heat coils of the refrigerator.

57. The method of claim 56 wherein the adjusting comprises adjusting a time of the defrost operations.

58. The method of claim 54 wherein the adjusting comprises adjusting anti-sweat operations of the refrigerator using the one of the loads comprising a heater configured to heat an exterior portion of a cabinet of the refrigerator.

59. The method of claim 54 wherein the adjusting comprises adjusting interior air circulation operations of the refrigerator using the one of the loads comprising a fan.

60. The method of claim 54 wherein the adjusting comprises adjusting cooling operations of the refrigerator using the one of the loads comprising a compressor.

61. The method of claim 60 wherein the adjusting comprises varying a speed of the compressor.

62. The method of claim 60 wherein the adjusting comprises performing a hot gas bypass operation.

63. The method of claim 54 wherein the providing comprises providing the refrigerator comprising a multi-stage refrigerator having a plurality of cooling stages, and the adjusting comprises adjusting to operate at less than the available number of cooling stages.

64. An electrical appliance energy consumption control method comprising:

providing an electrical appliance coupled with a power distribution system, the appliance comprising a plurality of loads;

receiving electrical energy within the appliance from the power distribution system;

operating the appliance at a normal mode of operation wherein one of the loads consumes a first amount of electrical energy;

monitoring an electrical characteristic of electrical energy of the power distribution system; and

responsive to the monitoring, operating the appliance at an other mode of operation wherein the one of the loads consumes a second amount of electrical energy different than the first amount of electrical energy.

65. The method of claim 64 wherein the monitoring comprises monitoring the electrical characteristic comprising frequency of the electrical energy.

66. The method of claim 65 wherein the monitoring comprises monitoring the frequency of the electrical energy distributed to the appliance by the power distribution system.

67. An electrical energy consumption system comprising:

a power interface configured to receive electrical energy of the power distribution system;

a plurality of loads coupled with the power interface and configured to consume the received electrical energy; and

control circuitry configured to monitor an electrical characteristic of the electrical energy of the power distribution system and to vary an amount of consumption of the received electrical energy via one of the loads responsive to the monitoring.

68. The system of claim 67 wherein the control circuitry is located proximate to the loads.

69. The system of claim 67 wherein the power interface is configured to receive the electrical energy from a node of the power distribution system and the control circuitry is coupled with the node.

70. The system of claim 69 wherein the control circuitry is configured to monitor the electrical characteristic of the electrical energy received via the node.

71. The system of claim 67 wherein the loads comprise loads of a single appliance.

72. The system of claim 71 wherein an other of the loads receives a constant supply of electrical energy before and after the varying.

73. The system of claim 67 wherein the control circuitry is configured to monitor the electrical characteristic comprising frequency of the electrical energy.

74. The system of claim 73 wherein the control circuitry is configured to monitor the frequency of the electrical energy received by the power interface from the power distribution system.

75. The system of claim 67 wherein the control circuitry resides within a housing of an appliance which comprises the plurality of loads.

76. A compressor system comprising:

a compressor configured to compress a fluid;

a condenser configured to condense the fluid;

an evaporator configured to evaporate the fluid; and

control circuitry configured to monitor electrical energy supplied to the compressor and to control short circuiting of the condenser and the evaporator responsive to the monitoring to reduce an amount of electrical energy consumed by the compressor compared with an other operational mode.

77. The system of claim 76 wherein the control circuitry is configured to monitor the electrical energy received at a physical location of the compressor.

78. An HVAC system comprising:

equipment configured to consume a first amount of electrical energy during operations to adjust a temperature of an area associated with the HVAC system; and

control circuitry configured to monitor the electrical energy supplied to the HVAC system at a physical location of the HVAC system, and to control the equipment to operate in a mode wherein a second amount of electrical energy is consumed by the HVAC system less than the first amount.

79. The system of claim 78 wherein the control circuitry is configured to control the equipment responsive to the monitoring.

80. The system of claim 79 wherein the control circuitry is configured to monitor an electrical characteristic of the electrical energy to monitor the electrical energy.

81. The system of claim 80 wherein the control circuitry is configured to monitor the electrical characteristic comprising frequency of the electrical energy.

82. A clothes dryer comprising:

a heating element configured to control a temperature of a compartment of the clothes dryer configured to dry clothes;

a tumbler motor configured to rotate the clothes in the compartment; and

control circuitry configured to monitor electrical energy provided to at least one of the heating element and the tumbler motor and to control at least one of the heating element and the tumbler motor to operate in a mode of operation wherein a reduced amount of electrical energy is consumed by the clothes dryer compared with an other operational mode and responsive to the monitoring of the electrical energy.

83. The dryer of claim 82 wherein the control circuitry is configured to monitor the electrical energy provided at a physical location of the clothes dryer.

84. A clothes washer comprising:

a heating element configured to control a temperature of water used to wash clothes using the clothes washer;

an agitator motor configured to agitate the clothes being washed; and

control circuitry configured to monitor electrical energy provided to at least one of the heating element and the agitator motor and to control at least one of the heating element and the agitator motor to operate in a mode of operation wherein a reduced amount of electrical energy is consumed by the clothes washer compared with an other operational mode and responsive to the monitoring of the electrical energy.

85. The washer of claim 84 wherein the control circuitry is configured to monitor the electrical energy provided at a physical location of the clothes washer.

86. A water management system comprising:

a heating element configured to control a temperature of water within an associated reservoir;

a circulation motor configured to circulate water within the reservoir; and

control circuitry configured to monitor electrical energy provided to at least one of the heating element and the circulation motor and to control at least one of the heating element and the circulation motor to operate in a mode of operation wherein a reduced amount of electrical energy is consumed by the water management system compared with an other operational mode and responsive to the monitoring of the electrical energy.

87. The system of claim 86 wherein the control circuitry is configured to monitor the electrical energy provided at a physical location of the water management system.

88. A dish washer comprising:

a water heating element configured to adjust a temperature of water used to wash dishes using the dish washer;

a forced air heating element configured to adjust a temperature of air used to dry the dishes using the dish washer; and

control circuitry configured to monitor electrical energy provided to at least one of the water heating element and the forced air heating element and to control at least one of the water heating element and the forced air heating element to operate in a mode of operation wherein a reduced amount of electrical energy is consumed by the dish washer compared with an other operational mode and responsive to the monitoring of the electrical energy.

89. The dish washer of claim 88 further comprising a water pump, and wherein the control circuitry is configured to control the water pump to operate in a mode of operation wherein a reduced amount of electrical energy is consumed by the water pump compared with an other operational mode of the water pump.

90. The dish washer of claim 88 wherein the control circuitry is configured to monitor the electrical energy provided at a physical location of the dish washer.

91. A personal computer system comprising:

a component of the personal computer system configured to operate in an energy saving mode; and

control circuitry configured to monitor electrical energy provided to the component of the personal computer system and to control the component to operate in the energy saving mode wherein a reduced amount of electrical energy is consumed by the personal computer system compared with an other operational mode, and wherein the controlling is responsive to the monitoring of the electrical energy.

92. The system of claim 91 wherein the control circuitry is configured to monitor the electrical energy provided at a physical location of the personal computer system.

93. The system of claim 91 wherein the component comprises a peripheral component.

94. The system of claim 91 wherein the component comprises a display.

95. The system of claim 91 wherein the component comprises a microprocessor of the control circuitry.

96. A water heater comprising:

a water heating element configured to control a temperature of water within a reservoir of the water heater; and

control circuitry configured to monitor electrical energy provided to the water heating element at a physical location of the water heater, and wherein the control circuitry is configured to control the water heating element to operate in a mode of operation wherein a reduced amount of electrical energy is consumed by the water heater compared with an other operational mode and responsive to the monitoring of the electrical energy.

97. The water heater of claim 96 wherein the control circuitry is configured to monitor an electrical characteristic of the electrical energy to monitor the electrical energy.

98. The water heater of claim **97** wherein the control circuitry is configured to monitor the electrical characteristic comprising frequency of the electrical energy.

99. A refrigerator comprising:

a plurality of components configured to perform operations with respect to refrigeration of goods within the refrigerator; and

control circuitry configured to monitor electrical energy provided to at least one of the components and to control at least one of the components to operate in a mode of operation wherein a reduced amount of electrical energy is consumed by the refrigerator compared with an other operational mode and responsive to the monitoring of the electrical energy.

100. The refrigerator of claim **99** wherein the control circuitry is configured to monitor the electrical energy provided at a physical location of the refrigerator.

101. The refrigerator of claim **99** wherein the at least one component comprises a thermostat.

102. The refrigerator of claim **99** wherein the at least one component comprises a heating element.

103. The refrigerator of claim **99** wherein the at least one component comprises a circulation fan.

104. The refrigerator of claim **99** wherein the at least one component comprises a compressor.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 7,010,363 B2
APPLICATION NO. : 10/462307
DATED : March 7, 2006
INVENTOR(S) : Donnelly et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Title Page, Inventors, line 8, please delete “Boberly-Bartis” after “Anne Marie” and insert --Borbely-Bartis--.

Title page 2, “FOREIGN PATENT DOCUMENTS”, please delete GB 2361 114A 10/2001” after “EP 1 372 238 A1 12/2003” and insert --GB 2361 118A 10/2001--.

Col. 7, line 16, please delete “of” after “operation” and insert --of)--.

Col. 14, line 35, claim 34, please delete “**31**” after “claim” and insert --**33**--.

Signed and Sealed this

Twenty-second Day of August, 2006

JON W. DUDAS
Director of the United States Patent and Trademark Office