US 20050116814A1

(19) United States
(12) Patent Application Publication
(10) Pub. No.: US 2005/0116814 A1
Rodgers et al.
(43) Pub. Date: Jun. 2, 2005

(54) INTELLIGENT POWER MANAGEMENT CONTROL SYSTEM

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(21) Appl. No.: **10/972,508**

(22) Filed: **Oct. 25, 2004**

**Related U.S. Application Data**

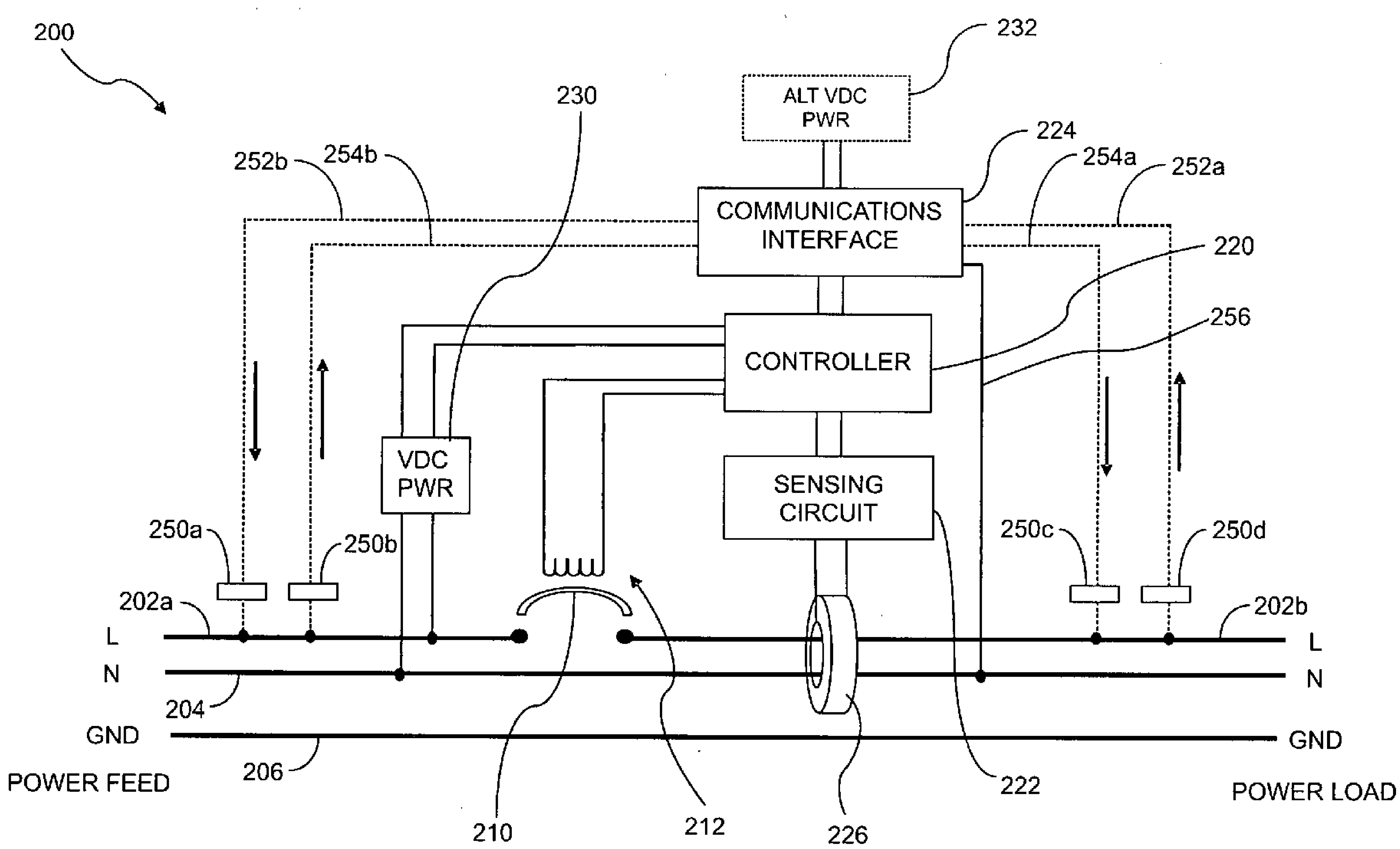
(60) Provisional application No. 60/513,962, filed on Oct. 24, 2003.

**Publication Classification**

(51) Int. Cl.[7] ....... **H02H 5/04**
(52) U.S. Cl. ....... **340/310.01**

(57) **ABSTRACT**

An intelligent power management system that includes a circuit breaker containing a PLC module that spans open contacts of the circuit breaker to provide a communication path for PLC messages between the line and load sides of the circuit when the contacts are open. The contacts are motorized to permit remote operation through PLC messaging. Coupled to the PLC module is a controller, which controls the opening and closing of the motorized contacts under user control or via an adaptive load management algorithm that reduces peak power consumption and adapts a set of loads to changed power supply conditions. The controller can also dynamically alter operational current and fault threshold levels on a real-time basis based upon circuit requirements or environmental conditions. The algorithm runs a state machine and also manages loads in a limited power source environment such as when loads are powered by a generator.



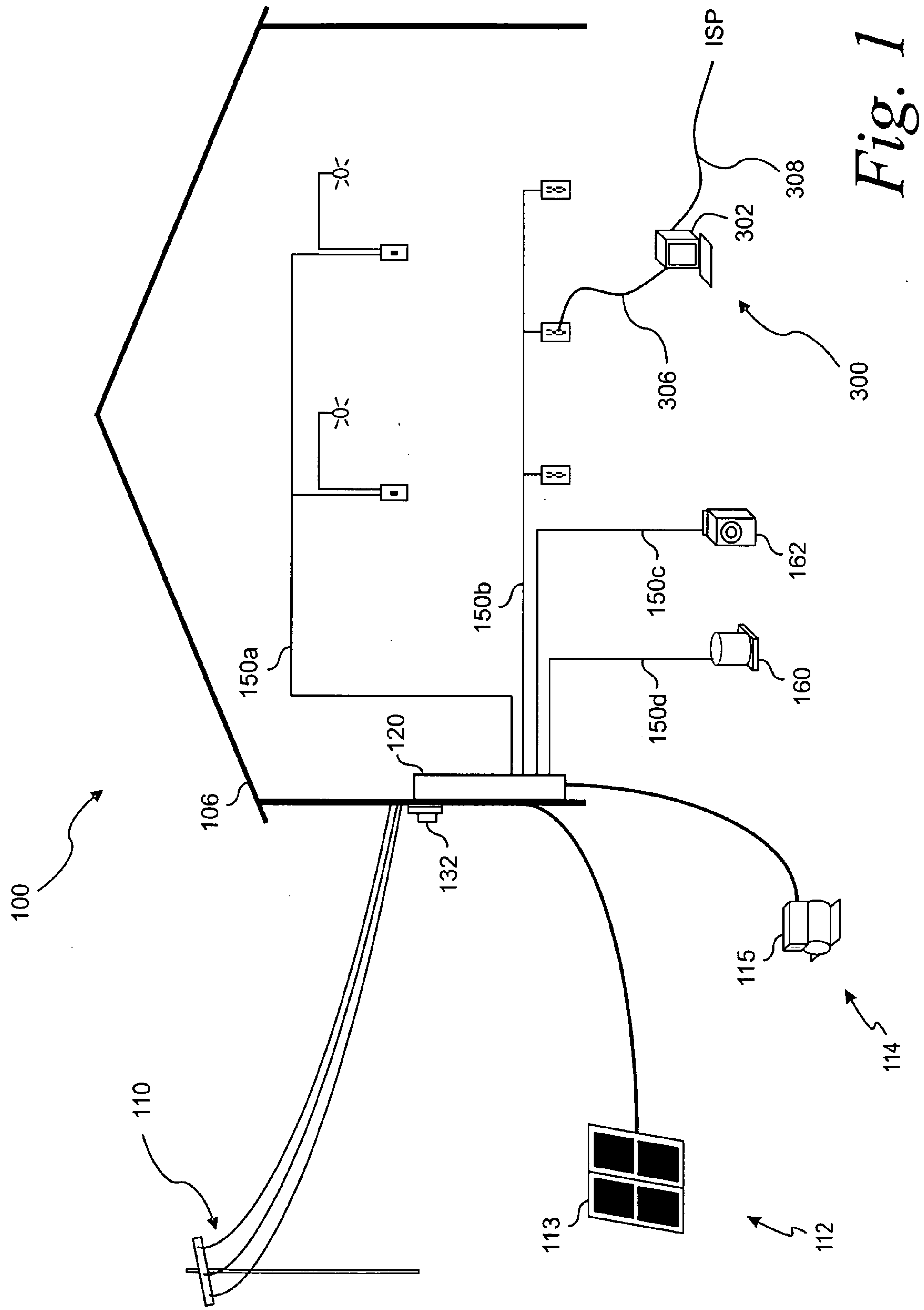

100
106
110
112
113
114
115
120
132
150a
150b
150c
150d
160
162
300
302
306
308
ISP

*Fig. 1*

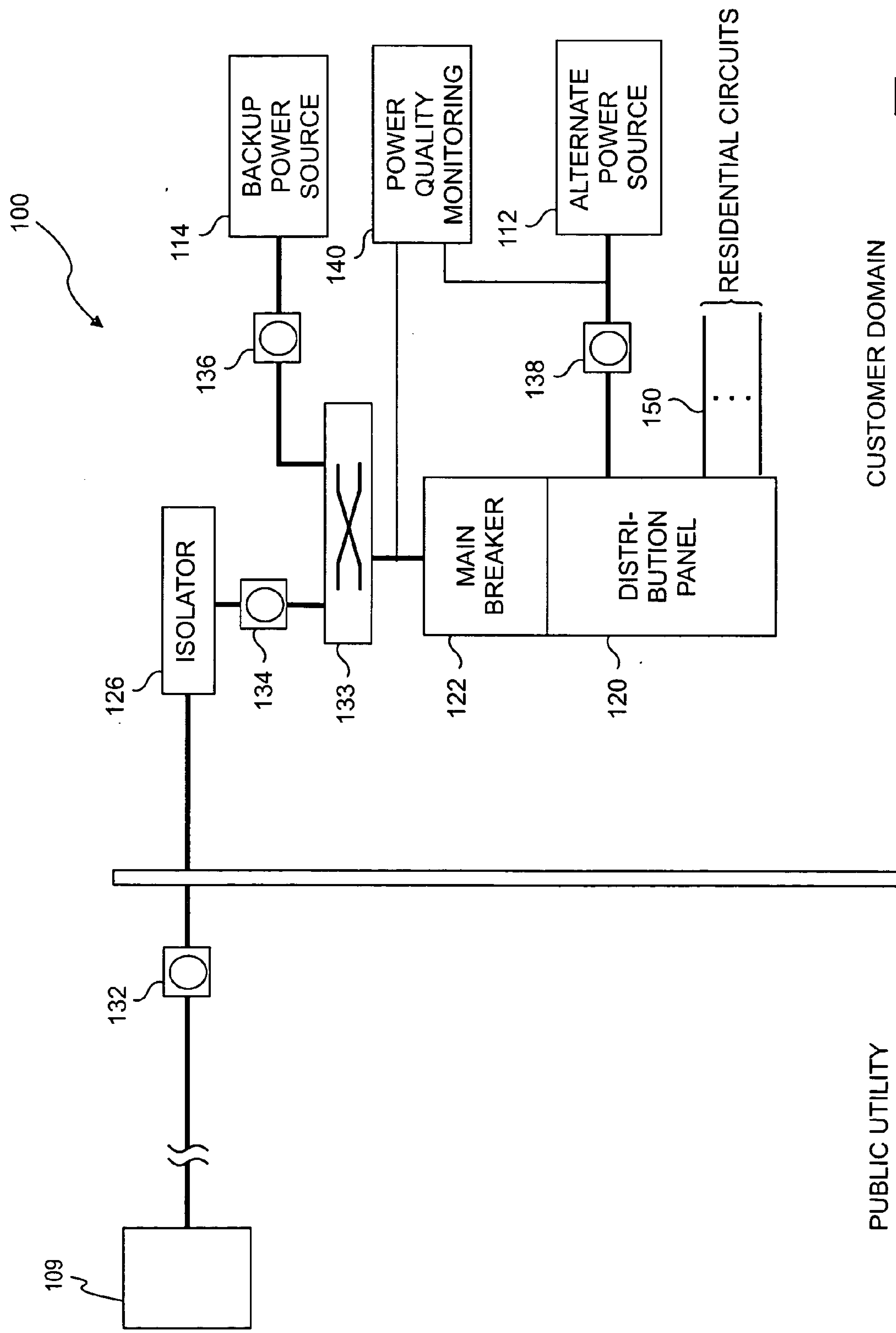

100
BACKUP POWER SOURCE
114
POWER QUALITY MONITORING
140
ALTERNATE POWER SOURCE
112
RESIDENTIAL CIRCUITS
136
138
150
ISOLATOR
126
134
133
MAIN BREAKER
122
DISTRI-BUTION PANEL
120
132
109
CUSTOMER DOMAIN
PUBLIC UTILITY

*Fig. 2*

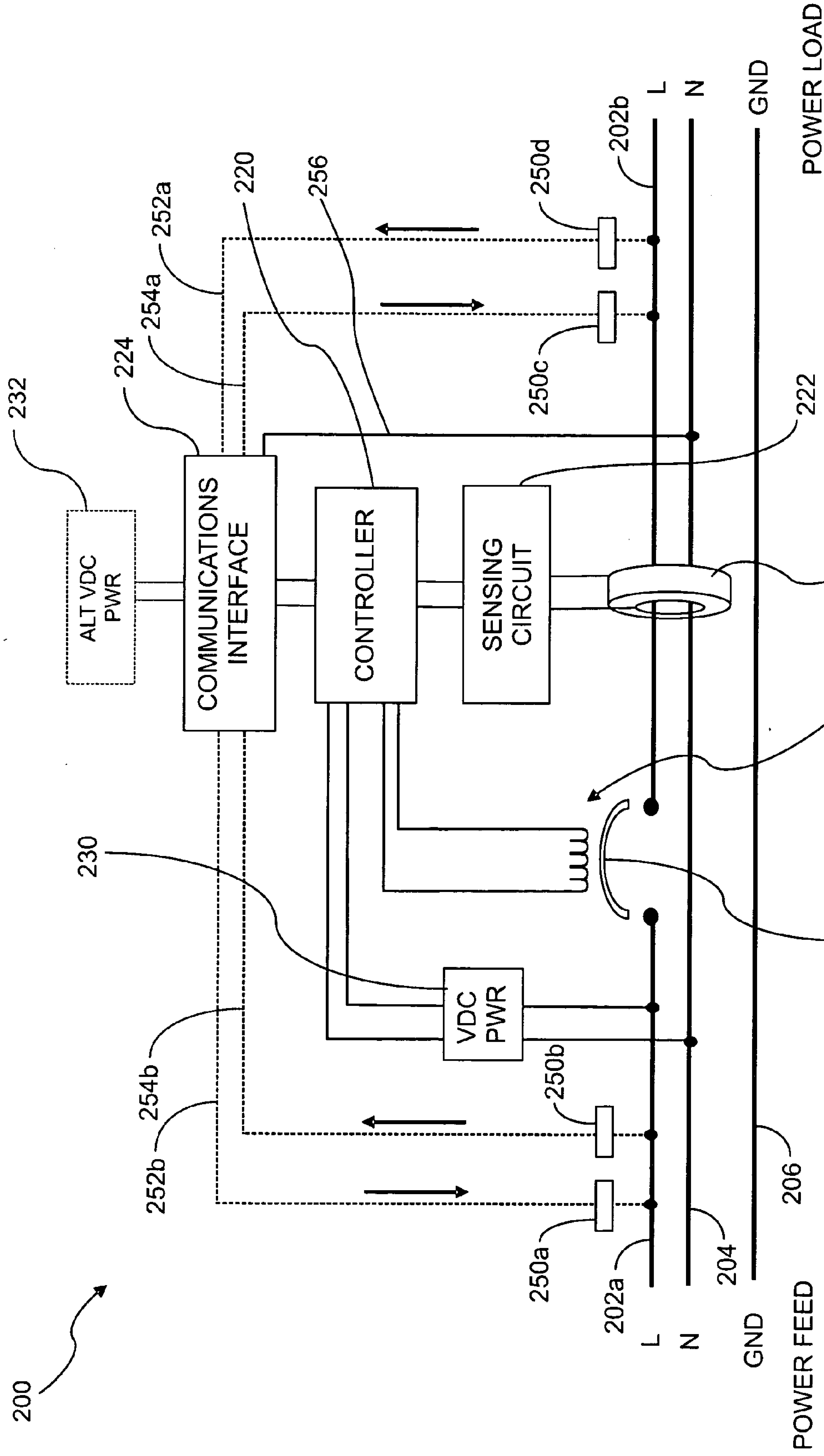

200
ALT VDC PWR
232
COMMUNICATIONS INTERFACE
224
CONTROLLER
220
SENSING CIRCUIT
222
VDC PWR
230
252a
254a
252b
254b
256
250a
250b
250c
250d
202a
202b
204
206
210
212
226
L
N
GND
POWER FEED
POWER LOAD

Fig. 3

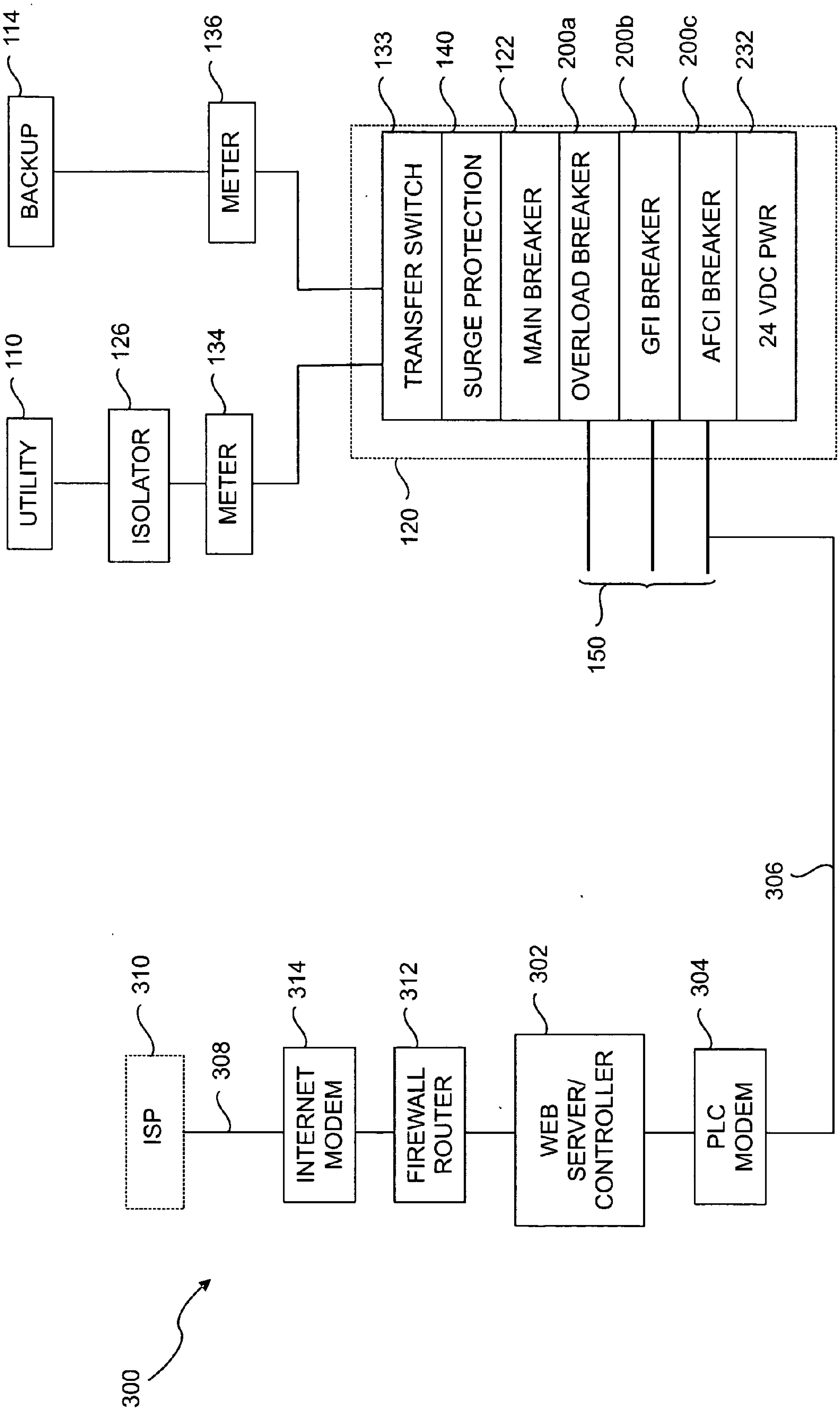
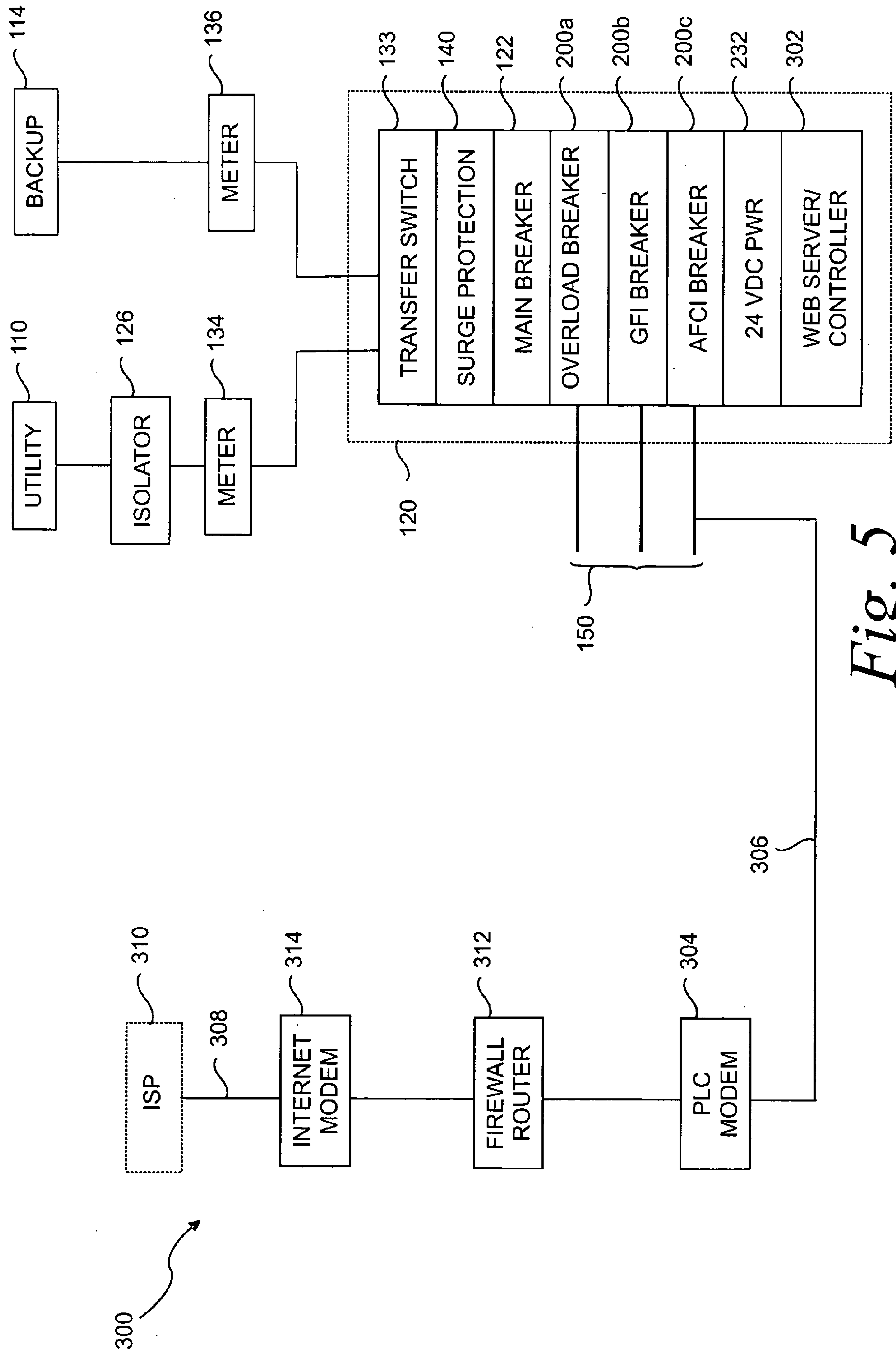

114
BACKUP
136
METER
110
UTILITY
126
ISOLATOR
134
METER
133
140
122
200a
200b
200c
232
TRANSFER SWITCH
SURGE PROTECTION
MAIN BREAKER
OVERLOAD BREAKER
GFI BREAKER
AFCI BREAKER
24 VDC PWR
120
150
306
310
ISP
308
314
INTERNET MODEM
312
FIREWALL ROUTER
302
WEB SERVER/ CONTROLLER
304
PLC MODEM
300

*Fig. 4*



BACKUP
114
METER
136
UTILITY
110
ISOLATOR
126
METER
134
TRANSFER SWITCH
133
SURGE PROTECTION
140
MAIN BREAKER
122
OVERLOAD BREAKER
200a
GFI BREAKER
200b
AFCI BREAKER
200c
24 VDC PWR
232
WEB SERVER/
CONTROLLER
302
120
150
306
ISP
310
308
INTERNET
MODEM
314
FIREWALL
ROUTER
312
PLC
MODEM
304
300


*Fig. 5*

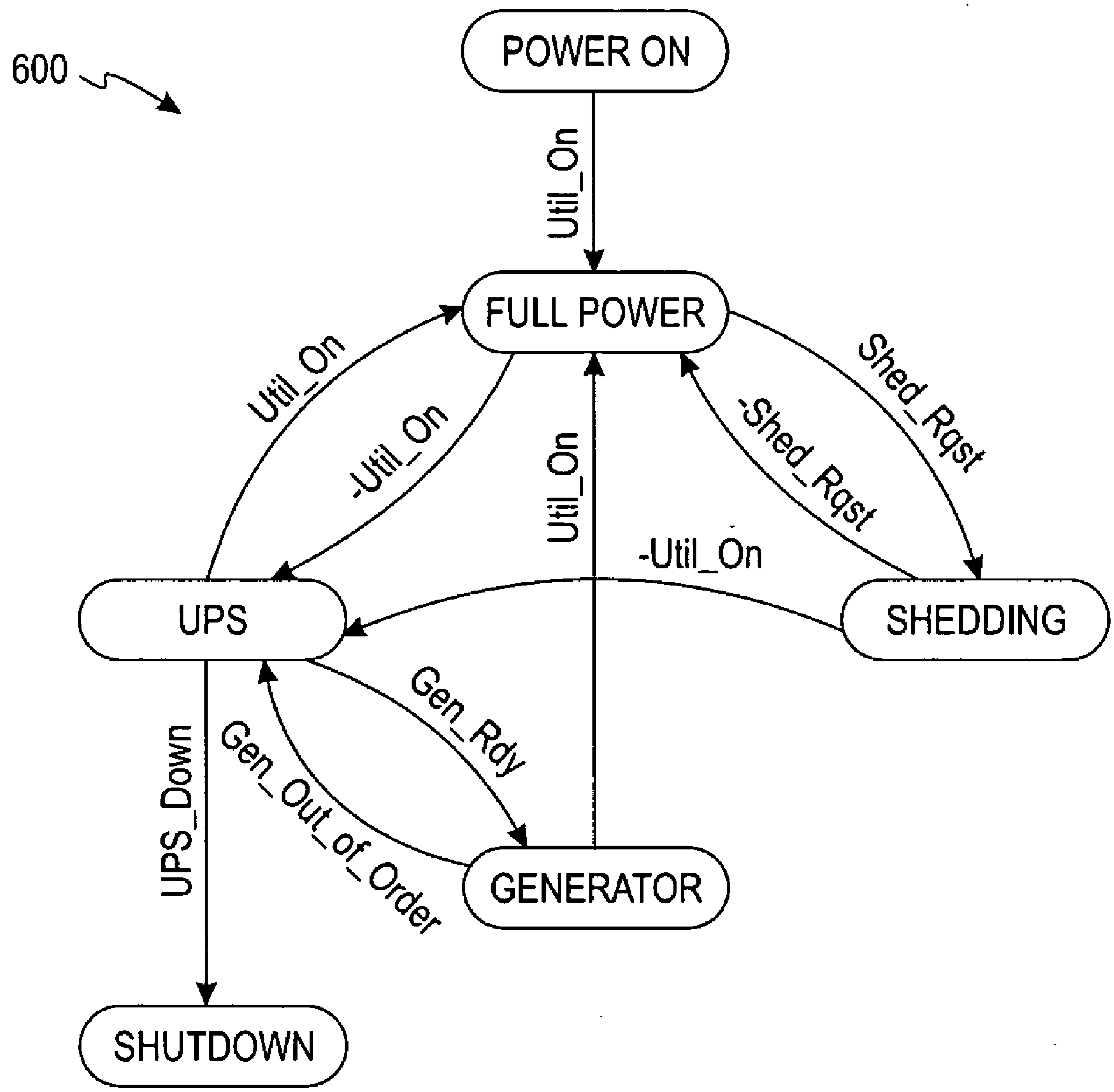

600
POWER ON
Util_On
FULL POWER
Util_On
-Util_On
Util_On
Shed_Rqst
-Shed_Rqst
-Util_On
UPS
SHEDDING
Gen_Rdy
Gen_Out_of_Order
UPS_Down
GENERATOR
SHUTDOWN

*Fig. 6*

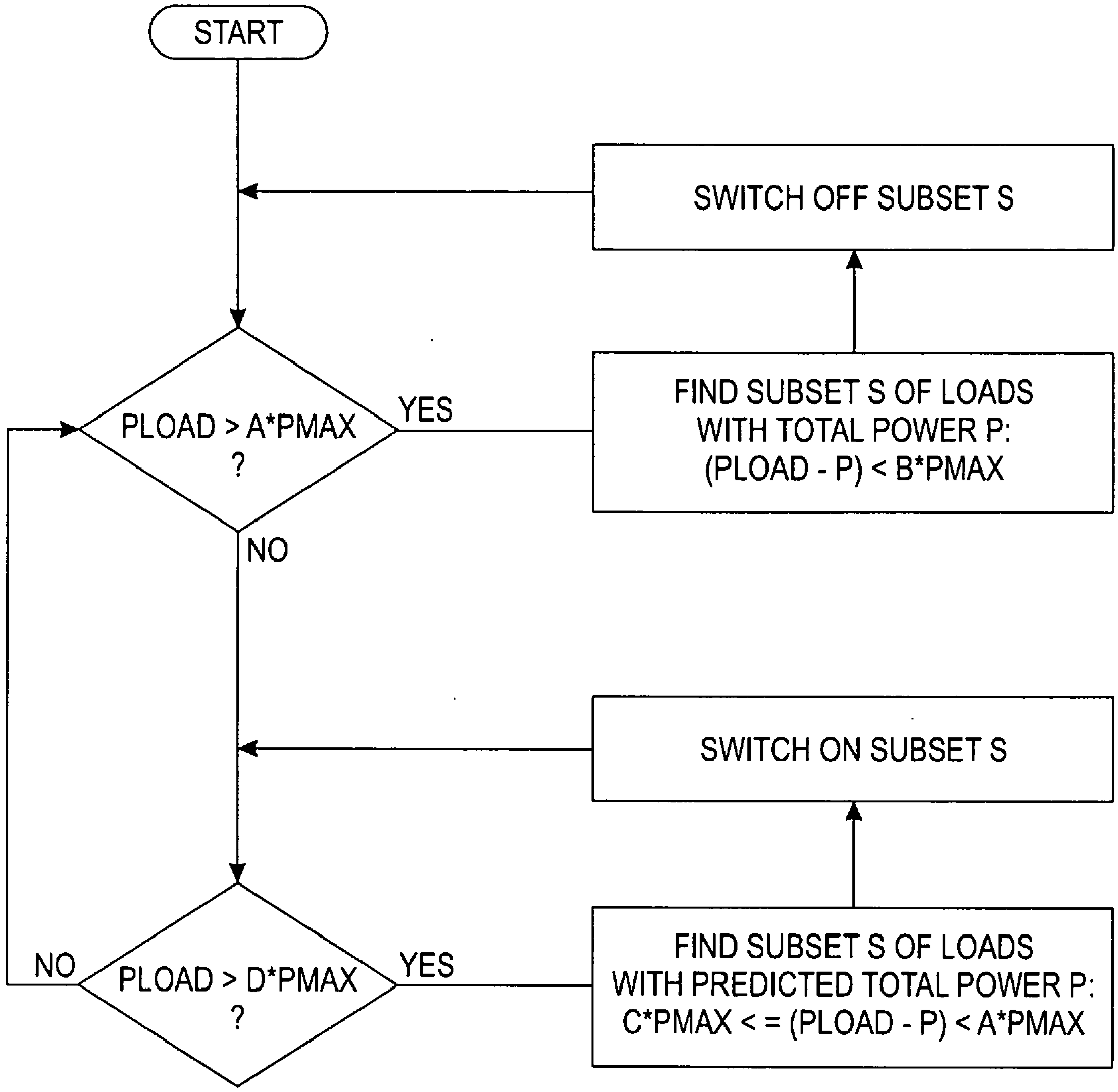

START
SWITCH OFF SUBSET S
PLOAD > A*PMAX
?
YES
FIND SUBSET S OF LOADS
WITH TOTAL POWER P:
(PLOAD - P) < B*PMAX
NO
SWITCH ON SUBSET S
NO
PLOAD > D*PMAX
?
YES
FIND SUBSET S OF LOADS
WITH PREDICTED TOTAL POWER P:
C*PMAX < = (PLOAD - P) < A*PMAX

*Fig. 7*

# INTELLIGENT POWER MANAGEMENT CONTROL SYSTEM

## CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to U.S. Provisional Application Ser. No. 60/513,962, filed Oct. 24, 2003.

## FIELD OF THE INVENTION

[0002] This invention is directed generally to power management control systems, and more particularly, to an intelligent power management control system.

## BACKGROUND OF THE INVENTION

[0003] Circuit breakers have long been used in industrial and residential applications to prevent damage to the loads connected to them and the building structures in which the loads are located. Normally, when an electrical fault or a current overload condition is sensed in a particular circuit, the breaker protecting that circuit "trips" and creates a physical disconnect in the circuit, thereby preventing the flow of electricity. To resume electrical flow to the circuit, the operator must physically reconnect the circuit breaker, typically by throwing a mechanical switch back to a closed position. These detection systems work automatically, tripping circuits only when certain conditions are satisfied.

[0004] However, an energy supplier or consumer may want to control energy flow deliberately to certain loads or circuits at such times as are desired, even when no fault or overload condition is detected. To do so, some way of remotely controlling the connections across the loads must be provided. But in the case of power line communication techniques, communication with any devices on the load side of the circuit breaker cannot occur if it has been tripped or if the electrical contacts inside the circuit breaker are otherwise separated. Thus, as soon as a circuit breaker trips, no further data can be collected on electrical devices connected to that circuit breaker nor can any further instructions be transmitted to change the behavior of the connected electrical devices. There is therefore a need to maintain the communication link from the utility or line side of the circuit breaker to the load side of the circuit breaker even when the circuit breaker has physically disconnected the branch circuit.

[0005] Another related need involves managing the loads or electrical devices connected to circuit breakers within a home or other facility in a way that is flexible and adaptable to both the homeowner and the power company. Homes typically can obtain their power from various sources, such as the power company, a backup generator, or an alternative power source like solar power arrays. Electrical devices (referred to as loads) within the home draw varying levels of electrical power at different times of the day and at different times of the year. Furthermore, electrical devices can be categorized and prioritized based on their consumption behavior (some loads cycle on and off throughout the day, other loads draw lots of power when they turn on) and importance (a life-saving medical device would be more critical than a swimming pool motor). For example, an oven can be used year-round and most frequently around dinnertime. An air conditioning unit can be used heavily during the summer months and not at all during the winter months. Data on the usage and properties of these and other electrical devices throughout the home can be collected over a period of time to create a set of historical data that reflects the usage patterns, usage frequency, usage levels of each device, and other properties about the electrical device.

[0006] During peak times in the summer months, the power company may wish to limit or reduce peak power consumption. Other emergency situations may call for a reduction or change in power consumption, such as adverse weather conditions or utility equipment failure. One approach to reducing power consumption is to initiate rolling blackouts, but this inconveniences homeowners and renders entire neighborhoods without power. What is needed, therefore, is an adaptive load management algorithm that overcomes these and other disadvantages. The present invention addresses this and other needs, as more fully described below.

## SUMMARY OF THE INVENTION

[0007] Briefly, according to an embodiment of the present invention, an intelligent power load management and control system and method and an adaptive load management algorithm are described and shown. The system generally includes a circuit breaker that has a communications interface (specifically a PLC module in some embodiments) that spans the open contacts across the line and load sides of a circuit such that the communications interface can still communicate even when the circuit breaker is tripped or the contacts are otherwise in an open position. The communications interface can be adapted to interface messages compatible with PLC, Ethernet, RS-45, or wireless schemes. The circuit breaker can further include a DC voltage supply to supply power to the circuit breaker components in the event of a trip event or loss of utility power.

[0008] The circuit breaker contacts are motorized so that they can be opened and closed remotely. A web server, optionally housed within the circuit breaker, communicates with the controller to cause the contacts to be opened or closed based on an adaptive load management algorithm in a specific embodiment or other criteria in other embodiments. The web server can also be configured to adjust dynamically the operational current, fault, or trip threshold levels of the circuit breaker. The adaptive load management algorithm can predict the behavior of loads connected to the circuit using a neural network predictor. The algorithm can also be used to adaptively manage loads under limited power circumstances when the circuit is being powered by a backup power supply, such as a generator. The algorithm can be applied regardless of the source of a request for changed power supply conditions-those sources can originate from a utility power source, an alternate power source, and/or a backup power source.

[0009] The foregoing and additional aspects of the present invention will be apparent to those of ordinary skill in the art in view of the detailed description of various embodiments, which is made with reference to the drawings, a brief description of which is provided next.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The foregoing and other advantages of the invention will become apparent upon reading the following detailed description and upon reference to the drawings.

[0011] **FIG. 1** is a functional block representation of an exemplary residential power distribution system;

[0012] **FIG. 2** is a functional block diagram of a residential power panel showing energy sources and load feeds according to an embodiment of the present invention;

[0013] **FIG. 3** is a functional representation of an intelligent circuit breaker device according to an embodiment of the present invention;

[0014] **FIG. 4** is a functional block diagram of a residential load management system and its components according to an embodiment of the present invention;

[0015] **FIG. 5** is a functional block diagram of a residential load management system and its components according to another embodiment of the present invention;

[0016] **FIG. 6** is a state machine diagram of an adaptive load management algorithm according to an embodiment of the present invention;

[0017] **FIG. 7** is a flow chart diagram of an adaptive load management algorithm for managing loads in a limited power source environment according to an embodiment of the present invention.

[0018] While the invention is susceptible to various modifications and alternative forms, specific embodiments have been shown by way of example in the drawings and will be described in detail herein. It should be understood, however, that the invention is not intended to be limited to the particular forms disclosed. Rather, the invention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

## DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

[0019] Referring now to the drawings, and initially to **FIG. 1**, a schematic representation of a residential power distribution system **100** is shown. A residence **106** is supplied power from an electrical power utility **109**, referred to herein as the power grid or power utility source **110** through a utility power meter **132**. Alternate energy sources **112** can also be present in the residential environment, such as solar panels **113**, full cells (not shown), wind vanes (not shown) or other methods of producing electrical energy. Standby or backup power sources **114** can also be present such as generators **115**, storage batteries, or an uninterruptible power supply, such as a UPS. Although a residential power distribution system **100** is shown in **FIG. 1**, it is understood that the present invention also applies to other types of power distribution systems, such as industrial or non-residential power distribution systems.

[0020] According to an embodiment of the present invention, the power sources **110**, **112**, and **114** are connected to a power distribution control panel **120**. The power distribution control panel **120** distributes electrical energy to various residential circuits **150***a-d*. Each circuit is connected to the power sources **110**, **112**, and **114** through a protective device in the power distribution control panel **120** such as an overload circuit breaker, not shown here, but discussed in greater detail below. In various embodiments, some or all circuit breakers to be managed by the present scheme are coupled to or include a branch circuit meter to provide data on the individual branch currents. Branch current monitors (BCMs) commercially available from Veris Industries are suitable (though not exclusively so) for this purpose.

[0021] The electrical circuits found within a residence or facility **106** are generally installed in a per-room and/or per-floor basis. For example, as shown here for simplicity, the circuit **150***b* has wall outlets for a specific group of rooms and the circuit **150***a* supplies electrical power to lighting systems for a specific group of rooms. In practice, lighting and electrical power outlets often share a circuit and the associated protective circuit breaker device.

[0022] Other electrical circuits that tend to be dedicated include environmental equipment such as air conditioning **160**, clothing washers and dryers **162**, heating, and audio-visual power circuits. Specialized outdoor circuits for swimming pool, yard lighting, and sprinkler systems can also be present in residential environments.

[0023] According to an embodiment of the present invention, the residential power distribution system **100** includes a power management system **300** that has a web server **302** connected to an internet service provider (ISP) by means of a conventional Internet connection **308**, e.g., cable modem, digital subscriber loop (DSL), etc. The web server **302** is connected by a power cable **306** or other network cable to a residential electrical power outlet from which it draws electrical energy. The web server **302** conventionally includes a controller.

[0024] A role of the web server **302** is to communicate messages throughout the residential power distribution system **100**. To do so, the web server **302** sends and receives power line communication (PLC) messages via a conventionally known PLC modem. Any PLC-controllable or PLC-messaging devices connected to the residential power distribution system **100** can communicate with the web server **302**, and can be controlled or monitored by PLC messaging via the web server **302**.

[0025] As mentioned above, the residential power distribution system **100** can include alternate energy sources **112** or backup power sources **114**, which can supply power to the residence **106** if power from the power utility source **110** is unavailable or diminished. However, these types of power sources have reduced power capacity as compared with the nearly infinite power capacity from the power utility source **110**, and therefore these alternate or backup sources need to be used sparingly in order to prolong their ability to supply power to the loads connected to them and to prevent overloading the source. In the current state of the art, when backup or standby power sources are used, they supply electrical power via dedicated circuits within the residence or facility **106** to sensitive equipment such as medical equipment. To provide these dedicated circuits requires rewiring or special wiring and leaves the remainder of the residence or facility without power during a loss of utility power. By employing the intelligent power distribution system of the present invention, electrical power can be made available to the entire house or facility **106** without rewiring, and distributed electrical devices connected to the electrical circuits can be controlled on a load basis through the power distribution control panel **120**.

[0026] Turning now to **FIG. 2**, a block diagram of the residential power distribution center **100** from **FIG. 1** is shown according to an embodiment of the present invention. Electrical power from a power utility grid **110** is connected to a utility power meter **132**, which is typically mounted on the exterior of a residence or facility **106** and is accessible to utility company personnel. Meters suitable for the utility power meter **132** are typically called revenue meters and are installed by the utility company. Meters suitable for user meters **134**, **136** and **138** include PM-850 PowerLogic™ meters. An isolator **126** can serve one or both of the following purposes: first, it prevents PLC messages used within the residence or facility **106** from being broadcast externally; and second, it prevents PLC messages present on the utility power line from entering the residence or facility **106**. In other embodiments, the isolator **126** is not supplied in order to permit communication between the utility and the residence **106**.

[**0027**] According to some embodiments, a user meter **134** is accessible to the user and allows the user to track and monitor the amount of electrical current and/or power used from the power utility source **110** on a real-time basis. The amount of electrical current and/or power from the backup power source **114** is monitored by a backup power monitor **136**. Power from the power utility source **110** and the backup power source **114** are coupled to a transfer switch **133**. The transfer switch **133** provides the user a way to control the source of residential power, and is present only when multiple power sources are available. Power from the transfer switch **133** is routed to the power distribution control panel **120** through the main breaker **122**.

[**0028**] According to another embodiment of the present invention, an alternate power source **112**, such as the solar panel array **113** or a wind vane, is also present. The alternate power source **112** supplies power to the distribution control panel **120** through another user-accessible power meter **138**, which allows the user to control the output power level of the alternate power source **112**. A separate, alternate power meter monitors the amount of electrical current and/or power delivered by the alternate power source **112**.

[**0029**] According to yet another embodiment of the present invention, a power quality monitor **140** monitors the quality of the energy received from the power utility source **110** or backup power source **114** and/or an alternate power source **112**. Power quality information is obtained from the power quality monitor **140** (or monitors) via PLC messaging or meters **132**, **134** and **138** via conventional serial communications by the power management system **300** described below.

[**0030**] User access and control to the various devices mentioned, e.g., the transfer switch **133**, the backup power source **114** and/or the alternate power source **112**, the power meters **134**, **136** and **138** as well as the power quality monitor **140** is accomplished, according to an embodiment of the present invention, by means of power line communication messaging. In other embodiments, user access and control can be carried out using other suitable communications messaging schemes, such as via Ethernet, RS-485, RS-232, Universal Serial Bus (USB), or wireless schemes.

[**0031**] Turning now to **FIG. 3**, a functional representation of an intelligent circuit breaker **200**, according to an embodiment of the present invention, is shown. The circuit breaker **200** is operatively connected to a line conductor **202** and a neutral conductor **204**. The line conductor **202** has a line side **202***a* and a load side **202***b*. A separate ground conductor **206** is also shown. A single pole breaker **200** is shown here as an illustrative example having contacts **210** on the line conductor **202**. In other embodiments, a double pole breaker having breaker contacts for each phase load line can be utilized for two-phase loads, such as clothes dryers **162**, HVAC units **160**, pool pumps, and the like.

[**0032**] Part of the circuit breaker **200** operates similarly to conventional circuit breakers. A conventional mechanical mechanism (not shown) is used to set or engage the breaker contacts **210**, which allow current to flow through the load conductor **202**. If the circuit breaker **200** trips, i.e., opens the breaker contacts **210**, because of a detected overload or fault condition, the breaker contacts **210** can only be reclosed manually by means of the aforementioned mechanical mechanism and cannot be reclosed remotely.

[**0033**] Current and/or fault sensing device(s) **226** are operatively coupled to the line and/or neutral conductors **202** and **204** depending on the type of current and/or fault sensing circuit used. The sensing device(s) **226** and sensing circuit **222** are exemplary only, and the configuration and deployment of these components is well known to those of ordinary skill in the art. The sensing circuit **222** is connected to the sensing device(s) **226** and to a controller **220**. According to an embodiment of the present invention, the controller **220** is a micro-controller. According to another embodiment of the present invention, the controller **220** is a special-purpose integrated circuit. According to yet another embodiment of the present invention, the current sensing circuit **222**, shown here to be a separate function, can be integrated into the controller **220**.

[**0034**] A communications interface **224** is coupled to the controller **220** and optionally coupled to an optional 24 VDC source **232**. The communications interface **224** can, in alternate embodiments, enable communications via PLC messaging, Ethernet, RS-485, or wireless communications schemes. The communications interface **224** can be a PLC module capable of handling PLC messaging schemes. The following discussion assumes that the communications interface **224** is a PLC module, however, it should be understood that the present invention is not limited to such communication scheme. One of the problems with PLC messaging is that when current state-of-the-art circuit breakers are in the open position the communication link is broken. To overcome this problem, the PLC module (communications interface **224**) spans the gap to provide a communication path between the line side of the circuit and the load side by means of power line couplers **250***a-d*. The power line couplers **250***a-d* are positioned to span the circuit breaker contacts **210** and to provide a communication path even when the circuit breaker contacts **210** are in the open or tripped position.

[**0035**] Signals from a messaging source on the load side **202***b* are sent across power line coupler **250***d* through the communication line **252***a* to the communications interface **224**. The communications interface **224** passes the message signal out the communication line **252***b* through the coupler **250***a* to the line side **202***a*. Couplers **250***b* and **250***d* and communication lines **254***a* and **254***b* are used for signals passing in the other direction—i.e., from the line side **202***a* to the load side **202***b*. According to another embodiment of the present invention, the communications interface **224** is also a repeater, used to boost the signal strength of the communication link between the line side and the load side of the circuit. According to yet another embodiment of the present invention, the communications interface **224** is also connected to the controller **220** and thus acts as a local modem. This connection allows for remotely communicating with and controlling the controller **220** and thereby the circuit breaker contacts **210**, as well as accessing the state of the circuit breaker **200** by means of PLC messaging. A message detected at the load and line side of the contacts would indicated that the contacts are in closed or in contact with one another. Signal strength of the two signals could also be compared on line and load side to access the open or closed state.

[**0036**] According to an embodiment of the present invention, an AC-to-DC power supply **230** that is integrated with the circuit breaker **200** provides DC power to the controller **220**, the sensing circuit **222**, and the communications interface **224**. The power supply **230** draws electrical energy off of the power lines **202***a*, **204** coupled to the circuit breaker contact **210**. According to an alternative embodiment of the present invention, DC power is obtained from an optional 24 VDC power source **232** to supply power to the circuit-breaker devices in the intelligent circuit breaker **200** as well as providing power for communication to other components of the power distribution control panel **120** and uses an uninterruptible power source to back-up the power to the optional 24 VDC power source **232**.

[**0037**] Variations in the controller **220**, the current sensing circuit **222**, and the sensing device(s) **226** can produce circuit breaker devices with different operating characteristics or combination of operating characteristics. These variations can affect the conditions under which a fault or overload is detected by the following devices within the circuit breaker: current overload device, ground-fault circuit interrupter, or arc-fault circuit detector.

[**0038**] When a fault or overload condition is detected, the controller **220** energizes a conventionally known trip mechanism **212** such as a solenoid or other mechanism, which physically opens the circuit breaker contacts **210**. Using the intelligent circuit breaker **200**, the operational current and fault threshold levels can be altered on a real-time basis depending on circuit requirements or environmental conditions. The alterations can include any of the following and be carried out automatically or under user control:

[**0039**] 1. Adjusting the GFI trigger levels. The intelligent circuit breaker **200** can change the trip point, for example, from 5 mA to 30 mA depending on the application.

[**0040**] 2. Calibrating any sensing element, such as sensing device(s) **226** to account for variations in the loads.

[**0041**] 3. Dynamically lowering or raising the trip threshold levels of the intelligent circuit breaker **200** to account for variances in the construction of various loads, for example. A load on a dedicated circuit, such as a refrigerator, can be monitored over time, and a new threshold can be established once a sufficient amount of load data has been accumulated. The threshold levels can also be set during the manufacturing process or during final installation to account for variability of component material.

[**0042**] According to an embodiment of the present invention, the controller **220** controls aspects of the power line communication. A PLC module (communications interface **224**) is connected to both the line side of the power conductor **202***a* and the load side of the power conductors **202***b*. This allows power line communication to occur across open circuit breaker contacts **210**, thereby permitting access to PLC-capable devices connected to the load side of the power conductors. It also allows PLC messages to be communicated to and from the line side **202***a* of the contacts **210**. In such a configuration, an additional connection **256** from the communications interface **224** to the neutral conductor **204** is required. According to other embodiments of the present invention, the communications interface **224** is incorporated into the controller **220** or special purpose integrated circuit.

[**0043**] The intelligent circuit breaker **200** can be powered by a 24 volt DC source (shown generically as the AC-to-DC power supply **230** in **FIG. 3**) connected to the line side of the circuit and draws its power from the un-switched line conductors **202***a* and **204** so that the intelligent circuit breaker **200** remains powered even when the circuit breaker contacts **210** are open. The AC-to-DC power supply **230** can be housed within the circuit breaker **200**. According to another embodiment of the present invention, the AC-to-DC power supply **230** contained within the circuit breaker **200** also has an uninterruptible power source, such as a battery or U.P.S., to provide communication power during a power interruption. According to another embodiment of the present invention, the optional 24 VDC power source **232** exists to power the components of the power distribution control panel **120**. This 24 VDC power source **232** also provides an uninterruptible power source to ensure PLC communications. The 24 VDC power source **232** supports power line communications even when the utility power is not in service and no alternative or backup power **112**, **114** sources is available.

[**0044**] Because the breaker contacts **210** are under control of the controller **220**, they can be opened or closed remotely (such as by a conventionally known motorized mechanism) and without manual intervention even when no overload or fault condition exists. An example of such a circuit breaker is found within the G3 PowerLink™ motorized circuit breaker panel and also found in the QOPL PowerLink™ Circuit Breaker, although any other suitable remote operable circuit breaker can be used. The breaker contacts **210** are opened or closed in this manner by messages, such as PLC messages or messages in Ethernet packets, from a central load management system **300**, such as the one described below in connection with **FIG. 4**.

[**0045**] In some embodiments of the present invention, the status of the intelligent circuit breaker **200** can be queried by the load management system **300** or similar residential control unit. The expected statuses of the intelligent circuit breaker **200** include, but are not limited to:

[**0046**] 1. Engaged, closed

[**0047**] 2. Disengaged, open, i.e., manually open, not controllable

[**0048**] 3. Tripped, cause of trip (overload, fault, etc.)

[**0049**] 4. Open, i.e., commanded open and reclose-able

[0050] **FIG. 4** illustrates a functional block diagram of a load management system **300** that depicts components of the power distribution control panel **120**. A power feed from the power utility source **110** provides electrical energy to the power distribution control panel **120**. The isolator **126**, on the utility power feed line, prevents PLC or other communication signals from external line-side sources from being broadcast internally and also prevents internal load-side PLC or other communication signals from being broadcast externally. The isolator **126** is particularly useful in multi-dwelling units, preventing one unit from accessing or controlling power levels to another unit. In embodiments where such communication is desired, the isolator **126** is omitted. The backup power source **114** supplies power to the distribution control panel **120** when power from the power utility source **110** is unavailable or diminished. User-accessible meters **134** and **136** monitor the usage of electrical energy of the utility power source **110** and the backup power source **114**, respectively.

[0051] Generally, the power distribution control panel **120** can, in alternate embodiments, include any combination of a controllable transfer switch **133**, a surge protector **140**, a main breaker **122**, an overload breaker **200***a*, a GFI breaker **200***b*, an AFCI breaker **200***c*, and a 24 VDC power supply **232**. The breakers **200***a-c* are connected to electrical circuits **150**, some or all of which can be protected by the surge protector **140** in various embodiments.

[0052] The transfer switch **133** selects the source of electrical power, such as utility or standby/backup power. In the event of a utility power failure, the transfer switch **133** can switch the source of electrical power from the power utility source **110** to the backup power source **114**. In a specific embodiment, the surge protector **140** protects the entire residence or facility **100**.

[0053] The circuit breakers **200***a-c* are not meant to represent an exhaustive list. The circuit breakers have a mechanical, manual set and reset mechanism, and an optional override switch. According to an embodiment of the present invention, the functional state of the circuit breaker is detectable. A partial list of such functional circuit-breaker state information includes:

[0054] 1. Manual off

[0055] 2. Engaged

[0056] 3. Tripped

[0057] 4. Remote off.

[0058] The 24 VDC power supply **232** supplies power to various components in the power distribution control panel **120** and enables PLC message communication and remote operation of the circuit breakers **200***a-c*. Although the 24 VDC power supply **232** is shown as a separate block in **FIG. 4** as supplying power to all of the components in the distribution control panel **120**, it can in other embodiments be incorporated into individual components within the control panel **120**, such as in any one or more of the circuit breakers **200***a-c*.

[0059] The dynamic load management system **300** further includes an Internet modem **314** coupled to an Internet Service Provider (ISP) **310**, a firewall router **312**, a web server **302**, and a PLC modem **304**. In an embodiment, the web server **302** obtains power from a wall outlet by means of a power cord **306** and is capable of sending power line control (PLC) messages by means of the PLC modem **304** through the power cord **306** to an electrical circuit **150**. Alternatively, in other embodiments, the web server **302** obtains its power from the 24 VDC power supply **232** optionally housed within the circuit breaker **200** or in the distribution control panel **120**. Software running on the web server **302** is responsive to user configuration and command information to display a variety of electrical status information, to control alternate power sources, and to limit power usage, such as by carrying out an adaptive load management algorithm **600** described in connection with **FIGS. 6 and 7** below. The power utility company **109** can thus access the distribution control panel **120** over the Internet via the user's ISP, allowing the power company to take advantage of the existing infrastructure and technology without having to reconfigure the power grid for use as a communications network, although such reconfiguration is within the scope of the present invention.

[0060] As noted above, although the present discussion refers to PLC messaging, the present invention is not limited to PLC messaging but rather contemplates other communication schemes such as Ethernet, RS-485, or wireless communication schemes, to name a few. For example, in an embodiment employing an Ethernet communication scheme, the PLC modem **304** can be replaced by a conventional Ethernet controller. Similarly, for a wireless communication scheme, the PLC modem **304** can be replaced by an 802.11 wireless controller.

[0061] The Internet modem **314** can be any conventional Internet modem, such as a cable modem, digital subscriber loop (DSL) modem, or a wireless modem, to name a few. The ISP allows commands and information to be communicated externally from the residence or facility **100**. For example, the user can access, monitor, and control from a remote location via the ISP **310** the loads connected to the electrical circuits **150** by logging into or otherwise gaining access to the web server **302**. In some embodiments, the web server **302** receives commands from the power utility **110** or passes messages to the power utility **109**. The power utility **109** has access to the web server **302** through internet access across the user's firewall **312**. In these embodiments, for example during peak power demand periods or during emergencies, the power utility **109** can disable certain electrical loads or initiate rolling blackouts to selected loads connected to the power grid. By way of example only, during a peak power demand, the power utility **109** can disable or cycle air conditioning units or swimming pool motors in selected facilities connected to the power grid **110** on a rolling basis by sending appropriate messages via the Internet to each facility's web server **302**, which in turn communicates a message to the appropriate breaker in the distribution control panel **120** to remotely disengage the contacts across the breaker to which the air conditioning unit is connected thereby preventing that unit from receiving power.

[0062] To address "Big Brother" concerns, the user can allow or disallow the utility company access to certain loads. For example, to avoid the furnace motor from being cycled or turned off during peak periods of electrical usage, the user can disallow remote access to that load. Of course, the user can grant himself such access, in case he leaves for an extended vacation and forgets to turn the furnace off, for example, in order to save electricity.

[0063] Utility companies can provide incentives for power reduction in the form of rebates or other utility rate guarantees. For example, users who sign up for a power reduction program and agrees to grant the power utility company **109** remote access to the distribution control panel **120** can receive rebates or a reduction in the rate available to users who do not take advantage of the program. Regardless of whether the power utility companies **109** have access to the distribution control panel **120**, the present invention allows the user great flexibility in remotely controlling and monitoring the loads connected to the control panel **120**.

[0064] For example, the user can use dynamic load management to limit the electrical power consumption by self-imposed limitations based on occupancy, power consumption, power efficiency, cost-of-power considerations, time-of-day or time-of-year pricing and/or real-time pricing. When an alternate power source **112** is present, it can be selected to supply part of the residential load. According to another embodiment of the present invention, when an alternate power source **112** is present power can be supplied backwards onto the utility grid **110**. The user meter **134**, provides the user with information on the amount of power fed onto the power grid **110**. The power meters **132** and **134** are also accessible to the power utility **109** so that rebates, etc. can be applied to the customer's account when excess electricity is so obtained.

[0065] The Internet-connected web server **302** can communicate with weather forecasting services to protect against lightning damage and other weather-related occurrences. Designated circuits, such as those supplying electrical power to sensitive equipment, can be shut down, unless overridden, to offer a further degree of protection even when surge protection is used. This is especially useful when the occupants are away from the residence or facility **100**.

[0066] According to an embodiment of the present invention, when there is a loss of power from the power utility source **110**, alternate power sources **112** or backup power sources **114** are switched into the residence **100**. When a standby or backup power source **114**, such as a power generator **115** is used, commands can be sent over the PLC link to start the power generator **115**. An uninterruptible power source (not shown), which usually is a battery or set of batteries, maintains the devices that use the PLC link.

[0067] During utility power source **110** failures the backup power source **114** is usually unable to supply all of the needs of the residence. Therefore, a new set of user-configurable guidelines are used to configure the dynamic load management system **300** based on the capacity of the backup power source **114** or the alternate power source **112** or a combination of local energy sources. Therefore, according to an embodiment of the present invention, designated circuits have a priority over non-designated circuits for power, however, electrical power is still available to the entire residence. Conventional systems utilizing backup power generally run dedicated circuits to supply power to selected systems requiring rewiring and a loss of power elsewhere in the residence.

[0068] According to another embodiment of the present invention, when there is a failure of the power grid such as a dangerous undervoltage condition, there is an opportunity to protect equipment using induction motors from brownout conditions by turning off the designated circuits supplying such equipment. When the brownout condition ceases, power can be restored by the dynamic load management system **300**. During excessive overvoltage conditions, the loads can be similarly shut off to protect the power distribution system of the residence or facility **100**.

[0069] In **FIG. 5**, the configuration is the same as shown in **FIG. 4** except that the web server **302** is incorporated into the distribution control panel **120** in **FIG. 5**. The web server **302** in the configuration shown in **FIG. 5** can be powered by the AC-to-DC power supply **230** or the 24 VDC power supply **232** optionally housed within the distribution control panel **120**.

[0070] To reduce peak power consumption and to accommodate an existing set of loads to changed power supply conditions, the present invention uses an adaptive load management algorithm **600** shown in state machine form in **FIG. 6**. The changed power supply conditions can include: switching to the alternate power source **112** or to the backup power source **114**, a request from power utility **109** to "shed" a load, etc. The adaptive load management algorithm **600** of the present invention preserves as much as possible the functionality of the system. For example, household loads could be rearranged to comply with changing power supply requirements and still perform their functions if the available power supply is only slightly lower than the demand. If the power demand increases, the most important loads can stay online while the least important could be disconnected. The decision to switch the load on or off is made on the basis of the importance (priority) of the load, and/or historical data regarding the load behavior gathered beforehand by the dynamic load management system **300**.

[0071] The adaptive load management algorithm **600** of the present invention learns the behavior of the loads as well as the load properties available for some loads in order to make the best guess regarding the best load-control strategy. The algorithm is preferably applied to residential installations, but could be also used in any other installations. The same adaptive load management algorithm **600** can be applied regardless of the power source, whether it be the utility power source **110**, the alternate power source **112**, or the backup power source **114**.

[0072] Conditions of a limited power could arise during emergency situations such as bad weather conditions resulting in power outages, utility equipment failure, or higher electricity cost hours. Usually a simple disconnection of "not important" loads is used to comply with the restrictions. For example, an existing practice is to shut down an HVAC unit when a power utility **109** requires "shedding" the load during peak hours. Or, in the case of backup power source **114**, a customer should chose a fixed, non-configurable set of loads to be turned on, while all other loads have to be shut down. Such selection normally has to be done during construction, when the distribution control panel **120** is installed. This inflexibility disadvantageously does not allow post-installation dynamic reconfiguration of the loads.

[0073] Power usage by a load is not constant. Some loads are cycling, like a refrigerator or hot water heater. Some loads (kitchen range or lights) could be switched on or off manually. Other loads have a significant in-rush current (air conditioning units, for example), which could be prevented from starting when the power source is unable to provide an overload current even for couple seconds. An optimal managing of the loads in such conditions is critical to keep as many loads functioning as possible.

[0074] To manage loads in the most flexible way, the decision-making process can be improved by learning more about the load-specific properties. For example, a refrigerator could present a health hazard if disconnected for a long time, so special attention is required for shedding it. The user also can apply a beforehand knowledge and learned data to dynamically change a set of loads that should be put on or off in each particular period of time. For instance, a dishwasher scheduled for running at 11:00 p.m. could be easily rescheduled to 3:00 a.m., if necessary, but it should not be shut down if it is already running. The same is true for cooking. Shutting down the range in the midst of food preparation to yield half-cooked food would ruin the meal.

[0075] Therefore, knowledge of the load properties, as well as its previous state, should be used to select the best order and time for running each load. The previous state is the state of the load before it was shut down and could be determined by monitoring the consumed power for a previous predetermined length of time. For instance, the kitchen range would cycle on and off to keep burner surface in a required temperature range. Thus, a zero immediate consumed power does not necessary mean that the burner is off. It could mean that the burner load is in an OFF part of the ON/OFF cycle, and therefore could return to ON state at any time.

[0076] The types of loads are categorized according to any of the following:

[0077] 1. Having significant in-rush current (HVAC, arrays of incandescent lights, etc.)

[0078] 2. Interruptible or not interruptible: for example, a hot water heater could be disconnected for a short period of time without much inconvenience (interruptible), but it can be desirable to have a TV set on all the time as long as it is being watched (not interruptible).

[0079] 3. Cycling or not cycling load: a cycling load could share the available power in different time slots, reducing the peak power.

[0080] 4. Acceptable for long (e.g., hours) interruptions or not. For example, a hot water heater could be disconnected for hours during the daytime when hot water consumption is low (acceptable), but a refrigerator must keep food cold and cannot be disconnected for long periods of time (not acceptable).

[0081] Power sources are categorized by any of the following:

[0082] 1. Ability to tolerate an overload: High (such as the utility power source **110**), Low (such as the backup power source **114**), and Zero (such as the alternate power source **112**). This category is important for starting the "high in-rush current" loads like a HVAC compressor.

[0083] 2. Ability of the different power sources **110**, **112**, and **114** to work synchronously: a typical solar cell inverter (alternate power source **112**) can, while a low-cost emergency generator **115** (backup power source **114**) normally cannot.

[0084] The adaptive load management algorithm **600** of the present invention carries out several goals. First, it works with a distribution system, such as the dynamic load management system of the present invention, which includes:

[0085] 1. Load center (panel board) such as the distribution control panel **120** equipped with either conventional (manual) and controllable (motorized) or controllable only (and no conventional) circuit breakers **200**. One such suitable distribution control panel **120** is the G3 PowerLink™ motorized circuit breaker panel.

[0086] 2. Branch circuit meters such as the sensing circuits **222** provide data on individual branch currents. Exemplary branch current monitors for this purpose are commercially available from Veris Industries.

[0087] 3. A controller adapted to communicate with a network, such as the web server **302**. An example of such a server is a PowerServer™ running Tridium-Niagara™.

[0088] 4. A network for communicating between the controllers, meters, panels, some loads, and user interface, such as the communications interface **224** and related interconnected devices shown in **FIGS. 3-4**.

[0089] Second, the adaptive load management algorithm **600** of the present invention provides a way to use a smaller size alternate power source **112** for emergency or reduced energy consumption for the house or facility **106**.

[0090] Third, the adaptive load management algorithm **600** of the present invention reduces (or "shaves") the power consumed by the loads during peak periods. It does so by sequencing the interruptible loads, briefly shutting down the interruptible loads to provide extra power for starting "high in-rush current" loads, or postponing the running of "low priority" loads. For example, a dishwasher could be rescheduled to run at nighttime, when the consumption is minimal.

[0091] Fourth, the adaptive load management algorithm **600** of the present invention reduces energy consumed during the "high energy cost" hours, as described above.

[0092] Fifth, the adaptive load management algorithm **600** of the present invention provides a smart adaptive management of loads when in restricted power mode (such as when power is supplied by a backup power source **114**, etc.) by at least any of the following:

[0093] 1. Monitoring each load (branch) to collect (learn) data on recent power consumption of the load to be able to predict possible consumption if the load is online.

[0094] 2. If the utility power source **110** has been shut down (because of an emergency or other reason), the adaptive load management algorithm **600** turns all loads off and, after the backup power source is on, turns a pre-calculated set of loads back on. The pre-calculated set of loads is determined based on predicted power consumption (calculated from historical data), the dynamic priority of each particular load, and available power.

[0095] 3. Dynamically changes the list of loads with time according to measured present power consumption, dynamic priority of each particular load, and availability of power from the backup power source **114**.

[0096] 4. Maintains the dynamic list of active loads according to a dynamic priority list, present state of the loads, and the power available from the backup power source **114**.

[0097] 5. Maintains the dynamic list of priorities for each load.

[0098] 6. Manages switching of the loads ON or OFF by controlling the load branches in the distribution control panel **120** using controllable circuit breakers **200**, or by communicating directly with loads and instructing them to change the ON/OFF state if the loads are capable for such a communication.

[0099] The adaptive load management algorithm **600** maintains a state machine that switches the system into one of predefined states. **FIG. 6** shows a state machine diagram of an embodiment of a state transition algorithm. Four states are illustrated: Full Power, Shedding, Generator, and UPS. Each of these states will be described next in further detail.

[0100] 1. Full Power state: the main power source (such as the power utility **110**) is running at fill power and does not request any restrictions. All loads are online. A "smart" algorithm can in some embodiments be applied to make the cycling loads share the same power using sequential time slots if possible to reduce peak power.

[0101] 2. Shedding state: the main power source requests reducing consumed power. Some less important loads are temporarily set offline to reduce power.

[0102] 3. Generator state: the utility power source **110** is out of service, so the system is powered from the alternative power source **112** (generator **115**, fuel cell, etc.). The adaptive load management algorithm **600** works to optimize the set of loads able to work with the limited power supply (discussed in further detail in connection with **FIG. 7**). A dynamic list of priorities is maintained for the loads reflecting a possible state change of the loads.

[0103] 4. UPS state: the system is running on the backup power source **114**. Only the most critical loads are online. In this state, the system waits until the backup power source **114** is online. If the backup power source **114** fails to come online, the system has to be shutdown.

[0104] Turning now to **FIG. 7**, the adaptive load management algorithm **600** for managing loads in a limited power source environment maintains a maximum possible number of loads online while keeping the total consumed power under the power source limit, Pmax. If the total load (Pload) is higher than a predefined part A of Pmax (for example 95%), then a subset S of online loads with lowest priorities and present total power consumption P is set offline to reduce the total consumption to lower than predefined part B of Pmax (for example 90%).

[0105] If the total load (Pload) is lower than a predefined part D of Pmax (for example 60%), then a subset S of offline loads with highest priorities and total estimated power consumption P is set online to increase the total consumption. The subset S is defined to increase the total consumed power to a level higher than predefined part B of Pmax (for example 70%) and not higher than part A of Pmax. It allows maximizing a number of loads able to work with a limited power source.

[0106] Coefficients A, B, C, and D are selected with respect to the following rule: $0<D<C<B<A<1.0$.

[0107] Historical data is used to estimate a power consumption of the loads that are supposed to be turned on. A load could cycle and/or have a significant in-rush current, so if the load was not consuming power just before being switched offline, it would be in the OFF stage of cycling and would consume significant power if suddenly brought online. Historical data would provide information on expected consumption from that load, particularly if an in-rush current is expected.

[0108] One difficulty in defining a correct set of the loads is the unknown state of the load after it has been in the OFF state for an extended period of time. While in the OFF state, the load could be changed by customer. For example, someone could switch a burner of the kitchen range on when the range was off, or the load can change itself (such as in the case where a refrigerator detects a temperature rise and tries to switch on). In both cases, the power consumed by a load after some OFF period of time could be different from power consumed just before it had been shut down. Therefore, the power that would be consumed by the load if it were switched ON needs to be estimated or predicted. A neural network predictor could be applied to predict the behavior of the particular load.

[0109] The adaptive load management algorithm **600** takes a maximum steady (not in-rush) current observed earlier as estimates, and defines a set of loads for putting online considering estimated load, priority of the loads, and power supply sources **110**, **112**, or **114**. Loads are then put online one by one with a short interval to reduce step-load effect. If the resulting power is still under a desired level, the process will be repeated until an optimal level is achieved.

[0110] The adaptive load management algorithm **600** also assists in starting up loads having a large in-rush current. To help to start such a load, the algorithm **600** briefly, for a second or two, shuts down all but the most important loads, starts the load in question with a large in-rush current, and finally puts all recently disconnected loads back online. This optional function can benefit systems working in hot climate regions, where the inconvenience of a brief shutdown of some devices would be much less important than the ability to run an air-conditioning unit from a backup power source **114**, such as the generator **115**.

[0111] Each state of the state machine of the adaptive load management algorithm **600** can have its own algorithm for initialization and operation. For example, the UPS state (**FIG. 6**) begins operation by shutting down all load brunches to prevent an overload of the emergency power source **114** when it comes online.

[0112] On entry, the Full Power state does not switch all loads ON at the same time, but instead switches them ON one by one to reduce step-loading of the utility power source **110** with a cumulative in-rush current. The Full Power state collects the historical data on consumed power for individual loads. It also communicates with any available "smart loads" to reduce peak power by intelligent scheduling or time-sharing.

**[0113]** The Generator state provides adaptive load management, or allows the user to choose what set of loads can be ON when a backup power source **114** is providing power. These sets could be predefined by the user or by the installer.

**[0114]** The Shedding state can utilize a time sharing to comply with a request from a power utility **109** for reducing consumed power.

**[0115]** While particular embodiments and applications of the present invention have been illustrated and described, it is to be understood that the invention is not limited to the precise construction and compositions disclosed herein and various modifications, changes, and variations can be apparent from the foregoing descriptions without departing from the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

**1**. A power management control system, comprising a circuit breaker having movable contacts connectable across a line side and a load side of a circuit, said circuit breaker including a communications interface electrically coupled across said contacts such that said communications interface communicates signals between the line side and the load side when said contacts are open.

**2**. The system of claim 1, wherein said communications interface is a power line communication (PLC) module.

**3**. The system of claim 1, wherein said signals include PLC messages.

**4**. The system of claim 1, wherein said signals include Ethernet-formatted packets.

**5**. The system of claim 1, further comprising a DC voltage supply connected to said communications interface.

**6**. The system of claim 5, wherein said DC voltage supply is housed within said circuit breaker.

**7**. The system of claim 1, wherein said contacts are motorized such that they can be remotely moved between open and closed positions through activation of said motor.

**8**. The system of claim 1, further comprising a controller operatively coupled to said communications interface, said controller programmed to receive and transmit said signals through said communications interface between the line side and the load side of said circuit.

**9**. The system of claim 8, further comprising a web server coupled to said controller, said web server including a web server controller programmed to communicate a command between a network external to said circuit breaker and said controller, said command directing said controller to cause said contacts to open.

**10**. The system of claim 9, further comprising a distribution control panel, said circuit breaker and said web server being housed within said distribution control panel.

**11**. The system of claim 9, wherein said web server is configured to receive an indication of an adverse weather condition and to communicate a message to said controller indicative of said indication, whereupon said controller is further programmed to cause said contacts to open thereby protecting loads connected to said circuit from effects of said adverse weather condition.

**12**. The system of claim 9, wherein said adverse weather condition is a lightning storm.

**13**. The system of claim 8, wherein said controller is programmable to associate a priority level with at least one load connected to said circuit, said priority level determining an order, from lowest to highest, in which loads connected to said system are shut down by causing contacts associated with the loads to be shut down to be opened.

**14**. The system of claim 8, wherein said signals include PLC messages, further comprising a PLC modem operatively coupled to said web server.

**15**. A method of facilitating communication across open contacts of a circuit breaker comprising:

connecting a communications interface across contacts of said circuit breaker such that said communications interface is connectable between the line side of a circuit to which said circuit breaker is to be connected and the load side of said circuit; and

configuring said communications interface to pass signals between the line side and the load side of said circuit regardless of whether said contacts are open or closed.

**16**. The method of claim 15, further comprising detecting which of at least two states said contacts are in, said at least two states being open and closed.

**17**. The method of claim 15, wherein said communications interface is a power line communication (PLC) module.

**18**. The method of claim 15, wherein said signals include power line communication (PLC) messages.

**19**. The method of claim 15, wherein said signals include Ethernet-formatted packets.

**20**. The method of claim 15, further comprising connecting said communications interface to a DC voltage supply.

**21**. The method of claim 15, further comprising:

operatively coupling a controller to said communications interface; and

programming said controller to receive and transmit said signals through said communications interface between the load side and the line side of said circuit.

**22**. The method of claim 21, further comprising coupling said controller to a motor operatively coupled to said contacts, and further programming said controller to move said contacts between an open and a closed position via said motor.

**23**. The method of claim 21, further comprising connecting said controller to a DC voltage supply housed within said circuit breaker.

**24**. The method of claim 21, wherein said controller includes a sensing circuit configured to receive signals representative of the current flowing through the load side of said circuit to which said circuit breaker is connectable.

**25**. The method of claim 21, wherein said controller is further programmed to dynamically alter a fault threshold level of said circuit breaker.

**26**. The method of claim 21, wherein said controller is further programmed to dynamically alter an operational current threshold level of said circuit breaker.

27. The method of claim 21, wherein said controller is further programmed to dynamically adjust a trip threshold of said circuit breaker.

28. The method of claim 21, wherein said controller is further programmed to cause said contacts to open in response to receiving a power line communication (PLC) message communicated through said communications interface from the line side of said circuit.

29. The method of claim 28, wherein said controller causes said contacts to open based on criteria selected from the group consisting of occupancy, cost of power, time-of-day pricing, and real-time pricing.

30. The method of claim 21, wherein said controller is further programmed to detect an imminent brownout condition on the line side of said circuit and, in response thereto, cause said contacts to open.

31. The method of claim 21, further comprising further programming said controller to sequence at least one interruptible load connected to said circuit based on an adaptive load management algorithm.

32. The method of claim 21, further comprising further programming said controller to execute an adaptive load management algorithm to temporarily shut down at least one interruptible load connected to said circuit to provide extra power for a high in-rush current load connected to another circuit.

33. The method of claim 21, further comprising further programming said controller to execute an adaptive load management algorithm to cause said contacts to open or close based on a priority associated with a load connected to said circuit.

34. The method of claim 21, wherein said controller is further programmed to cause said contacts open during at least a portion of a high energy cost time period.

35. The method of claim 21, wherein said controller is further programmed to substantially predict the behavior of at least one load connected to said circuit using a neural network predictor algorithm.

36. The method of claim 21, wherein said controller is further programmed to manage adaptively loads connected to said circuit when said circuit is powered by a backup power supply.

37. A power management control system, comprising:

a circuit breaker having movable contacts connectable across a line side and a load side of a circuit, said circuit breaker including:

a PLC module electrically coupled across said contacts such that said PLC module communicates PLC messages between the line side and the load side when said contacts are open,

a controller operatively coupled to said PLC module, said controller being programmed to:

receive and transmit said PLC messages through said PLC module between the line side and the load side of said circuit,

cause said movable contacts to move between an open position and a closed position, and

dynamically alter a property of said circuit breaker,

said circuit breaker further including a voltage supply connected to said controller.

38. The system of claim 37, wherein said controller is programmed to cause said movable contacts to move between an open and a closed position based on an adaptive load management algorithm.

39. A power management control system, comprising:

a distribution panel;

a transfer switch in said distribution panel, said transfer switch having a switch selectable between at least two power sources;

at least one circuit breaker in said distribution panel, said at least one circuit breaker having contacts connectable across a line side and a load side of a circuit, said contacts being movable between an open position and a closed position; and

a controller operatively coupled to said transfer switch and to said at least one circuit breaker, said controller including programmed instructions to cause said transfer switch to select one of said at least two power sources and to cause said contacts to be moved between said open position and said closed position.

40. The system of claim 39, further comprising a server programmed to pass signals received from a network external to said distribution panel to said controller.

41. The system of claim 40, wherein said external network includes the Internet.

42. The system of claim 40, wherein said server is in said distribution panel.

43. The system of claim 40, wherein said server is a web server, said web server including said controller.

44. The system of claim 40, wherein said controller is in said distribution panel.

45. The system of claim 40, wherein said controller is external to said distribution panel.

46. The system of claim 39, further comprising a DC voltage power source connected to said controller.

47. The system of claim 39, wherein said at least two power sources include a utility power source and a backup power source.

48. The system of claim 39, further comprising a branch current meter coupled to said circuit breaker.

49. The system of claim 39, wherein said at least one circuit breaker includes a communications interface electrically coupled across said contacts such that said communications interface communicates signals between the line side and the load side when said contacts are open.

50. The system of claim 49, wherein said at least one circuit breaker further includes a controller operatively coupled to said communications interface, said controller programmed to receive and transmit said signals through said communications interface between the line side and the load side of said circuit.

51. The system of claim 39, wherein said programmed instructions include an adaptive load management algorithm to cause said contacts to move between said open position and said closed position based on a priority associated with a load connected to the circuit to which said at least one circuit breaker is connected.

52. The system of claim 39, wherein said system is connectable to multiple circuits, each circuit being protected by a circuit breaker in said distribution panel, each circuit having a plurality of loads connected thereto, one of such circuits being protected by said at least one circuit breaker,

said programmed instructions including an adaptive load management algorithm to associate a priority level with at least some of the loads protected by their associated circuit breakers, said priority level determining a sequence in which said at least some of the loads are shut down by causing contacts of the circuit breakers associated with said loads to be shut down to be opened.

**53**. A method for adaptively managing a plurality of loads, comprising:

prioritizing, using a controller coupled to a plurality of circuit breakers connectable to a respective plurality of loads, at least some of the loads connectable to said circuit breakers based on at least one criterion; and

causing contacts of at least one of said plurality of circuit breakers to be remotely moved between an open position and a closed position based on said prioritizing.

**54**. The method of claim 53, further comprising creating a set of historical data reflecting a usage criterion of at least one prioritized load.

**55**. The method of claim 54, further comprising predicting future consumption of a load based on said set of historical data.

**56**. The method of claim 53, further comprising switching from a first power source to a second power source different from said first power source in response to a changed power supply condition.

**57**. The method of claim 53, further comprising storing a state of at least one of the prioritized loads.

**58**. The method of claim 53, wherein a first load is an interruptible load and a second load is a load having a high in-rush current requirement, further comprising shutting down said first load to provide additional power to start said second load.

**59**. The method of claim 53, further comprising establishing a pre-determined set of loads which are turned on responsive to a backup power source being switched on, and determining said pre-determined set of loads based on at least a priority of a load according to said prioritizing.

**60**. The method of claim 53, further comprising entering a limited power source mode that maximizes the number of loads online while maintaining the total consumed power under a pre-determined power source limit.

**61**. The method of claim 53, further comprising:

receiving an indication of an adverse weather condition; and

communicating a signal to a controller of one of said circuit breakers to cause contacts thereof to open thereby protecting loads connected to said one of said circuit breakers from effects of said adverse weather condition.

**62**. The method of claim 53, further comprising:

connecting a communications interface across contacts of one of said circuit breakers such that said communications interface is connectable between the line side and the load side of the circuit to which said one of said circuit breakers is connected; and

configuring said communications interface to pass signals between the line side and the load side regardless of whether said contacts of said one of said circuit breakers are open or closed.

**63**. The method of claim 53, further comprising detecting which of at least two states said contacts are in, said at least two states being open and closed.

**64**. The method of claim 53, further comprising dynamically altering a fault threshold level of one of said circuit breakers.

**65**. The method of claim 53, further comprising dynamically altering an operational current threshold level of said circuit breaker.

**66**. The method of claim 53, further comprising dynamically adjusting a trip threshold of said circuit breakers.

**67**. The method of claim 53, further comprising detecting an imminent brownout condition on the line side of the circuit and, in response thereto, causing contacts of at least one of said circuit breakers to open.

**68**. The method of claim 53, further comprising predicting the behavior of at least one of said loads using a neural network predictor algorithm.

**69**. The method of claim 53, wherein said prioritizing and said causing are carried out regardless of the source of a request for changes in power supply conditions.

**70**. The method of claim 69, wherein said source is selected from the group consisting of a utility power source, an alternate power source, and a backup power source.

**71**. The method of claim 70, wherein said alternate power source includes solar panels.

**72**. The method of claim 70, wherein said backup power source includes a generator.

**73**. The method of claim 70, wherein said backup power source includes an uninterruptible power supply.

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