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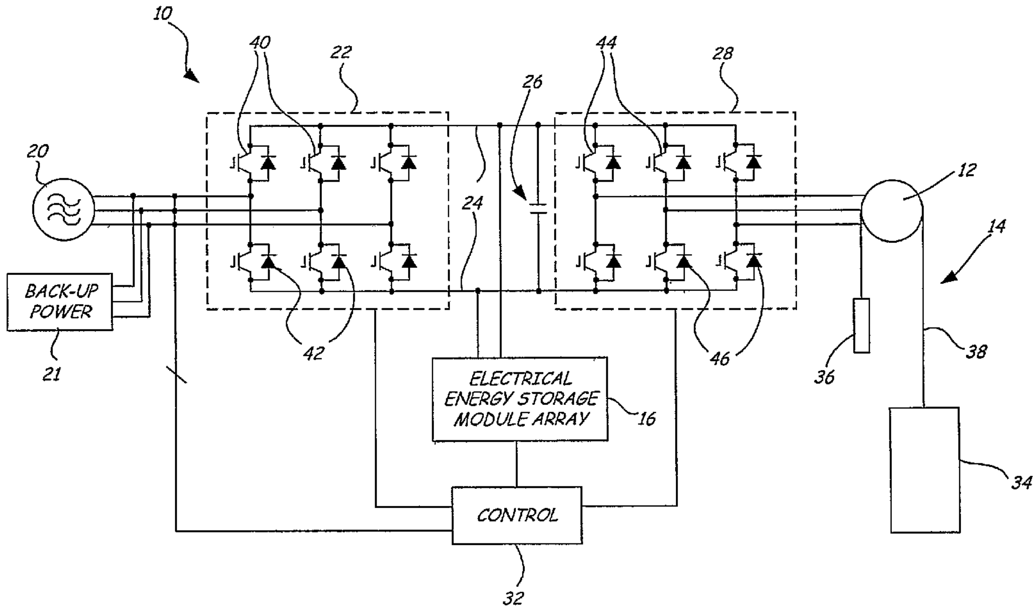
(54) **Title:** ELECTRICAL ENERGY STORAGE SYSTEM FOR DRIVING A LOAD



(57) **Abstract:** An elevator hoist motor (12) is driven by electrical energy storage (EES) modules (16) that are controlled such that at least one EES module drives the hoist motor (12) and at least one EES module charges. Subsequently, a controller (32) changes the at least one EES module that is driving the hoist motor (12) and the at least one EES module that is charging.

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ELECTRICAL ENERGY STORAGE SYSTEM FOR DRIVING A LOAD

BACKGROUND OF THE INVENTION

The present invention relates to the field of power systems. In particular, the present invention relates to an electrical energy storage system for driving a load, such as an elevator hoist motor.

An elevator drive system is typically designed to operate over a specific input voltage range from a power source. The components of the drive have voltage and current ratings that allow the drive to continuously operate while the power supply remains within the designed input voltage range. However, in certain markets the utility network is less reliable, where persistent utility voltage sags or brownout conditions (i.e., voltage conditions below the tolerance band of the drive) are prevalent. When utility voltage sags occur, the drive draws more current from the power supply to maintain uniform power to the hoist motor. In conventional systems, when excess current is being drawn from the power supply, the drive will shut down to avoid damaging the components of the drive.

When a power sag or power loss occurs, the elevator may become stalled between floors in the elevator hoistway until the power supply returns to the nominal operating voltage range. In conventional systems, passengers in the elevator may be trapped until a maintenance worker is able to release a brake for controlling cab movement upwardly and downwardly to allow the elevator to move to the next floor. More recently, elevator systems employing automatic rescue operation have been introduced. These elevator systems include electrical energy storage devices that are controlled after power failure to provide power to move the elevator to the next floor for passenger disembarkation. However, many current automatic rescue operation systems are complex and expensive to implement, and may provide unreliable power to the elevator drive after a power failure.

BRIEF SUMMARY OF THE INVENTION

The subject invention is directed to driving an elevator hoist motor with electrical energy storage (EES) modules that are controlled such that at least one EES module drives the hoist motor and at least one EES module charges. Subsequently, the controller changes the at least one EES module that is driving the hoist motor and the at least one EES module that is charging.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of a power system for driving an elevator hoist motor including an electrical energy storage (EES) storage module array.

FIGS. 2A-2C are schematic views of an EES module array including two EES modules in various operational states.

FIGS. 3A-3D are schematic views of an EES module array including n EES modules in various operational states.

DETAILED DESCRIPTION

FIG. 1 is a schematic view of power system 10 for driving hoist motor 12 of elevator 14 including electrical energy storage (EES) storage module array 16. Power system 10 also includes power supply 20, back-up power supply 21, power converter 22, power bus 24, smoothing capacitor 26, power inverter 28, and control block 32. Power supply 20 may be electricity supplied from an electrical utility, such as a commercial power source. Back-up power supply 21 may be a building back-up power source, such as a generator or a renewable power source, that is initiated in the event of failure of power supply 20. Elevator 14 includes elevator car 34 and counterweight 36 that are connected through roping 38 to hoist motor 12.

As will be described herein, power system 10 is configured to drive hoist motor 12 when power from power supply 20 is insufficient to drive hoist motor 12. For example, in certain markets the utility network is less reliable, where persistent utility voltage sags or brownout conditions (i.e., voltage conditions below the tolerance band of the drive) are prevalent.

Power system 10 according to the present invention allows for continuous operation of hoist motor 12 during these periods of irregularity. In addition, power system 10 may be configured to supplement power provided by power supply 20 to hoist motor 12 during normal operating conditions, such as to augment the power provided to power system 10 during periods of high power demand or to reduce the amount of power drawn from the electrical utility. While the following description is directed to driving an elevator hoist motor, it will be appreciated that EES module array 16 (and the control algorithm associated therewith) may be employed to drive any type of load.

Power converter 22 and power inverter 28 are connected by power bus 24. Smoothing capacitor 26 is connected across power bus 24. Power supply 20 provides electrical power to power converter 22. Power converter 22 is a three-phase power inverter that is operable to convert three-phase AC power from power supply 20 to DC power. In one embodiment, power converter 22 comprises a plurality of power transistor circuits including parallel-connected transistors 40 and diodes 42. Each transistor 40 may be, for example, an insulated gate bipolar transistor (IGBT). The controlled electrode (i.e., gate or base) of each transistor 40 is connected to control block 32. Control block 32 controls the power transistor circuits to convert the three-phase AC power from power supply 20 to DC output power. The DC output power is provided by power converter 22 on power bus 24. Smoothing capacitor 26 smoothes the rectified power provided by power converter 22 on DC power bus 24. It is important to note that while power supply 20 and back-up power supply 21 are shown as three-phase AC power supplies, power system 10 may be adapted to receive power from any type of power source, including (but not limited to) a single phase AC power source and a DC power source.

The power transistor circuits of power converter 22 also allow power on power bus 24 to be inverted and provided to power supply 20. In one embodiment, control block 32 employs pulse width modulation

(PWM) to produce gating pulses so as to periodically switch transistors 46 of power converter 22 to provide a three-phase AC power signal to power supply 20. This regenerative configuration reduces the demand on power supply 20. In another embodiment, power converter 22 comprises a three-phase diode bridge rectifier.

Power inverter 28 is a three-phase power inverter that is operable to invert DC power from power bus 24 to three-phase AC power. Power inverter 28 comprises a plurality of power transistor circuits including parallel-connected transistors 44 and diodes 46. Each transistor 44 may be, for example, an insulated gate bipolar transistor (IGBT). The controlled electrode (i.e., gate or base) of each transistor 44 is connected to control block 32. Control block 32 controls the power transistor circuits to invert the DC power on power bus 24 to three-phase AC output power. The three-phase AC power at the outputs of power inverter 28 is provided to hoist motor 12. In one embodiment, control block 32 employs PWM to produce gating pulses to periodically switch transistors 44 of power inverter 28 to provide a three-phase AC power signal to hoist motor 12. Inverter control 28 may vary the speed and direction of movement of elevator 14 by adjusting the frequency and magnitude of the gating pulses to transistors 44.

In addition, the power transistor circuits of power inverter 44 are operable to rectify power that is generated when elevator 14 drives hoist motor 12. For example, if hoist motor 12 is generating power, control block 32 controls transistors 44 in power inverter 28 to allow the generated power to be converted and provided to DC power bus 24. Smoothing capacitor 26 smoothes the converted power provided by power inverter 28 on power bus 24.

Hoist motor 12 controls the speed and direction of movement between elevator car 34 and counterweight 36. The power required to drive hoist motor 12 varies with the acceleration and direction of elevator 14, as well as the load in elevator car 34. For example, if elevator car 34 is being accelerated, run up with a load greater than the weight of counterweight 36 (i.e., heavy load), or run down with a load less than the weight of counterweight 36 (i.e., light load), a maximal amount of power is required to drive hoist motor 12. If elevator 14 is leveling or running at a fixed speed with a balanced load, it may be using a lesser amount of power. If elevator car 34 is being decelerated, running down with a heavy load, or running up with a light load, elevator car 34 drives hoist motor 12. In this case, hoist motor 12 generates three-phase AC power that is converted to DC power by power inverter 28 under the control of control block 32. The converted DC power may be returned to power supply 20, returned to EES module array 16, and/or dissipated in a dynamic brake resistor connected across power bus 24.

It should be noted that while a single hoist motor 12 is shown connected to power system 10, power system 10 can be modified to power multiple hoist motors 12. For example, a plurality of power inverters 28 may be connected in parallel across power bus 24 to provide power to a plurality of hoist motors 12. As another example, EES module array 16 may be connected to power bus 24 of each of a plurality of power systems 10 that drive a hoist motor 12. As a further example, a dedicated EES module array 16 may be provided for each of a plurality of power systems 10.

When power supply 20 is incapable of supplying sufficient power to drive hoist motor 12, such as due to a power failure or a scheduled or unscheduled brownout, or when supplemental power to power supply 20 during normal operation is desired (e.g., for power savings or for additional power during times of high power demand), electrical energy storage (EES) module array 16 provides power to power bus 24 to drive hoist motor 12. As will be further described herein, EES module array 16 includes a plurality of EES modules that each includes at least one electrical energy storage device, such as a supercapacitor or a secondary battery. The EES modules in EES module array 16 are controlled by control block 32 such that at least one of the EES modules operates to drive hoist motor 12 while at least one of the EES modules charges from a power source (e.g., power supplied by power supply 20 during a brownout condition, regenerated power from hoist motor 12, power from another of the EES modules in EES module array 16, power from back-up power source 21). At programmed time intervals, the control block 32 changes the at least one EES module that is driving hoist motor 12 and at least one EES module that is recharging. Thus, power is supplied to hoist motor 12 to provide supplemental power to power system 10 during normal operation, and to provide substantially uninterrupted service in the event that power from power supply 20 is insufficient to drive hoist motor 12. It should be noted that the use of programmed time intervals as described herein is only one approach to controlling EES module array 16. For example, EES module array 16 may also be controlled by control block 32 based on sensed voltage and current from EES module array 16 or the state of charge of the EES devices in EES module array 16.

FIG. 2A is a schematic view of EES module array 16 including two EES modules 50a and 50b. EES module 50a is connected to switch 52a that is controlled by a control signal from control block 32, and is operable to connect EES module 50a to power bus 24 in a first state and to a power source for charging in a second state. Switch 52a also has a third state that disconnects EES module 50b from both power bus 24 and the charging power source. EES module 50b is similarly connected to switch 52b such that EES module 50a may also be connected to either power bus 24 or the charging power source, or disconnected from both. It should be noted that switches 52 are merely for purposes of concisely illustrating the connectivity and interaction between EES modules 50, control block 32, power bus 24, and the charging power source, and in actual implementation switches 52 may be any devices that facilitate controllable connection of EES modules 50 to power bus 24 and the charging power source, including appropriately sized DC/DC converters.

EES modules 50a and 50b may include one or more devices capable of storing electrical energy that are connected in series or parallel. In one embodiment, EES modules 50a and 50b include at least one supercapacitor, which may include symmetric or asymmetric supercapacitors. In another embodiment, EES modules 50a and 50b include at least one secondary or rechargeable battery, which may include any of nickel-cadmium (NiCd), lead acid, nickel-metal hydride (NiMH), lithium ion (Li-ion), lithium ion polymer (Li-Poly), iron electrode, nickel-zinc, zinc/alkaline/manganese dioxide, zinc-bromine flow, vanadium flow, and sodium-sulfur batteries. EES modules 50a and 50b may include one type of EES devices or may include combinations of EES devices. Arrangements of supercapacitors, secondary batteries, other EES devices, and combinations thereof are provided in each EES module 50 to provide the requisite power and energy to drive hoist motor 12.

When power from power supply 20 is insufficient to drive hoist motor 12 (for example, as determined by a voltage sensor or other device connected to power bus 24 or power supply 20), or when power to supplement power supply 20 during normal operation is necessary or desired, control block 32 initiates operation of EES module array 16 to drive hoist motor 12. FIG. 2A shows an embodiment of EES module array 16 in a first operational state, in which the control signal from control block 32 actuates switch 52a to connect EES module 50a to power bus 24 via power bus connection 54. This causes the energy stored in EES module 50a to be provided on power bus 24, which drives hoist motor 12. In the first operational state, EES module 50b is idle (i.e., not electrically connected to either power bus 24 or the charging power source). EES module array 16 maintains this operational state for a period of time as controlled by control block 32. For example, control block 32 may be programmed to drive hoist motor 12 from EES module 50a for a time interval. This time interval may be related to the time required for the energy stored in EES module 50a to be insufficient to drive hoist motor 12. Alternatively, control block 32 may sense the energy level in EES module 50a (such as via a voltage or current sensor) to drive hoist motor

12 until the energy stored in EES module 50a is insufficient to drive hoist motor 12.

At the programmed time interval, control block 32 provides a signal to switches 52a and 52b, which changes EES module array 16 to a second operational state. In the second operational state, shown in FIG. 2B, switch 52a is actuated to connect EES module 50a to the charging power source via charging power source connection 56 and switch 52b is actuated to connect EES module 50b to power bus 24 via shared power bus connection 54. Thus, while EES module 50b provides stored power to power bus 24 to drive hoist motor 12, EES module 50a is recharging from a charging power source.

The charging power source may be any device or system capable of providing power to charge the EES devices of EES module 50a. For example, while power from power supply 20 may be insufficient to drive hoist motor 12, it may be sufficient to charge the EES devices in EES module 50a (e.g., during a brownout). Thus, EES module array 16 may be configured to receive charging power from power supply 20 on the charging power source connection 56, such as via a direct connection to power supply 20 or from a dedicated power converter connected between power supply 20 and charging power source connection 56. Also, when elevator car 34 drives hoist motor 12, the regenerated power from hoist motor 12 may be provided to EES module 50a through charging power source connection 56 (e.g., directly from hoist motor 12 or via a dedicated power inverter connected between hoist motor 12 and charging power source connection 56). In addition, in a system including multiple hoist motors 12, EES module array 16 may be configured to drive at least one hoist motor 12 while charging from regenerated power from other hoist motors 12. Furthermore, the charging power may be supplied from back-up power supply 21 or from a source external to power system 10. In some types of supercapacitors and secondary batteries, the transition from driving hoist motor 12 to charging may also require reversing the polarity of the voltage connected to EES module 50a, which results in a reversal of the chemical reactions in the EES devices.

After another time interval, control block 32 provides a signal to actuate switches 52a and 52b, which changes EES module array 16 to a third operational state. In the third operational state, shown in FIG. 2C, switch 52a is actuated to again connect EES module 50a to power bus 24, and switch 52b is actuated to connect EES module 50b to the charging power source. Consequently, EES module 50a, which was recharged in the second operational state, drives hoist motor 12, and EES module 50b, which powered hoist motor 12 in the second operational state, recharges.

Control block 32 subsequently switches EES module array 16 between the second operational state shown in FIG. 2B and third operational state shown in FIG. 2C at programmed time intervals. This process may continue until completion of all elevator dispatch requests existing when operation of EES module array 16 was initiated. Control block 32 may also continue the process of switching between the second operational state and the third operational state for a less definite period of time, such as until power supply 20 returns to normal operation, or until power from all sources has been dissipated. In the latter case, the available energy may be monitored by control block 32 to assure that energy does not run out while dispatch requests are still being processed by the elevator system.

After operation of EES module array 16 is terminated, control block 32 may control switches 52 to charge both EES modules 50 to full capacity for future availability in the event of another failure or sag in power supply 20. For example, control block 32 may connect both EES modules 50 to the charging power source at the same time, or may stagger the connection to the charging power source to limit the burden on the charging power source. In any case, when EES modules 50 are fully charged, control block 32 may put both EES modules 50 in an idle state (i.e., disconnect EES modules 50 from both power bus 24 and the charging power source) until power from EES module array 16 is again employed to drive hoist motor 12.

EES module array 16 may include any number of EES modules that are controlled by control block 32. To illustrate, FIG. 3A shows EES module array 16 including n EES modules 60a, 60b, 60c, ..., 60m, and 60n. The letter “n” is chosen to represent the last of an arbitrary number of EES modules 60, and the letter “m” is chosen to represent the second to last EES module 60. These labels should not be construed as limiting EES module array 16 to a certain number of EES modules 60.

EES modules 60 have properties substantially similar to the EES modules 50 shown in FIGS. 2A-2C, and may include at least one EES device such as supercapacitors, secondary batteries, and combinations thereof. EES module 60a is connected to switch 62a that is controlled by a control signal from control block 32, and is operable to connect EES module 60a to power bus 24 in a first state and to a power source for charging in a second state. The charging power source may be provided from a source similar to the charging power source described with regard to FIGS. 2A-2C, or the charging power source may be one of the other EES modules 60 in EES module array 16. Switch 62a also has a third state that disconnects EES module 60a from both power bus 24 and the charging power source. EES modules 60b-60n are similarly connected to switches 62b-62n, respectively, such that any of EES modules 60b-60n may also be connected to either power bus 24 or the charging power source, or disconnected from both. It should be noted that, similar to the embodiment shown in FIGS. 2A-2C, switches 62 are merely for purposes of concisely illustrating the connectivity and interaction between EES modules 60, control block 32, power bus 24, and the charging power source, and in actual implementation switches 62 may be any devices that facilitate controllable connection of EES modules 60 to power bus 24 and the charging power source.

When power from power supply 20 is insufficient to drive hoist motor 12, or when power to supplement power supply 20 during normal operation is necessary or desired, control block 32 initiates operation of EES module array 16 to drive hoist motor 12. FIG. 3A shows another embodiment of EES module array 16 in a first operational state, in which the control signal from control block 32 actuates switch 62a to connect EES module 60a to power bus 24 via power bus connection 64. This causes the energy stored in EES module 60a to be provided on power bus 24, which drives hoist motor 12. In the first operational state, EES module 60n is connected to the charging power source and EES modules 60b-60m are idle (i.e., not connected to either power bus 24 or the charging power source). Alternatively, all EES modules except for EES module 60a may be idle in the first operational state.

EES module array 16 maintains the first operational state for a period of time as controlled by control block 32. For example, control block 32 may be programmed to drive hoist motor 12 from EES module 60a for a time interval. This time interval may be related to the time required for the energy stored in EES module 60a to be insufficient to drive hoist motor 12. Alternatively, control block 32 may sense the energy level in EES module 60a to drive hoist motor 12 until the energy stored in EES module 60a is insufficient to drive hoist motor 12.

After a programmed time interval, control block 32 provides a signal to actuate switches 62, which changes EES module array 16 to a second operational state. In the second operational state, shown in FIG. 3B, switch 62a is actuated to connect EES module 60a to the charging power source via charging power source connection 66 and switch 52b is actuated to connect EES module 60b to power bus 24 via shared power bus connection 64. Thus, while EES module 60b provides stored power to power bus 24 to drive hoist motor 12, EES module 60a is recharging from a charging power source.

After another time interval, control block 32 provides a signal to actuate switches 62, which changes EES module array 16 to a third operational state. In the third operational state, shown in FIG. 3C, switch 62c is actuated to connect EES module 60c to power bus 24, switch 62b is actuated to connect EES module 60b to the charging power source, and switch 62a is actuated to place EES module 60a in an idle state (i.e., disconnected and not charging or discharging). Consequently, EES module 50b, which powered hoist motor 12 in the second operational state, recharges, while EES module 50c drives hoist motor 12.

At subsequent time intervals, control block 32 cycles through EES modules 60 in a similar fashion such that an EES module 60 is driving hoist motor 12 while an EES module 60 is charging. Thus, at the time interval at time n, control block 32 provides a signal to actuate switches 62, which changes EES module array 16 to an nth operational state. In the nth operational state, shown in FIG. 3D, switch 62m is actuated to connect EES module 60m to the charging power source, switch 62n is actuated to connect EES module 60n to the power bus 24, and all other switches 62 are positioned to place the remaining EES modules 60 in an idle state.

Control block 32 subsequently returns back to the first operational state and cycles through the n operational states shown in FIGS. 3A-3D. When EES module array 16 is employed during normal operation of power system 10, control block 32 cycles through the n operational states until supplemental power from EES module array 16 is no longer necessary or desired. In the event of a power failure, control block may cycle through the n operational states until completion of all elevator dispatch requests existing when operation of EES module array 16 was initiated. Control block 32 may also continue this process for a less definite period of time, such as until power supply 20 returns to normal operation, or until power from all sources has been dissipated. In the latter case, the available power may be monitored by control block 32 to assure that power does not run out while dispatch requests are still being processed by the elevator system. Control block 32 may be programmed to control current flows so as to maximize the duration of the extended service.

In FIGS. 3A-3D, a single EES module 60 is shown connected to power bus 24 and a single EES module 60 is shown connected to the charging power source during the various operational states. However, it should be noted that any number of EES modules 60 may drive hoist motor 12, any number of EES modules 60 may recharge during each of the operational states, and any number of EES module 60 may remain idle. For example, control block 32 may be programmed to connect two EES modules 60 to power bus 24 during each operational state, while two EES modules 60 recharge during each operational state, with the remaining EES modules 60 remaining idle. The number of EES modules 60 connected to power bus 24 and the charging power source during each operational state may be based on the capacity of the devices in each EES module 60.

In addition, while the charging and discharging of EES modules 60 has been described as occurring in a specific sequence and changing at specific time intervals, it should be noted that any sequence and timing of charging and discharging of EES modules 60 is contemplated by the present invention. For example, switching the EES modules 60 that are charging and switching the EES modules 60 that are discharging need not occur simultaneously. That is, control block 32 may switch the EES modules that are charging at a first time and the switch the EES modules that are discharging at a second time different from the first time. In addition, the timing of switching EES modules 60 among the charge and discharge processes can cover any range of time periods, from seconds to days. These time periods may be optimized based on the duty cycle of the elevator 14 (or a group of elevators), the physical properties of EES modules 60, the number of EES modules 60 in EES module array 16, and recommended protocols for charging and discharging EES modules 60 so as to extend their lifetimes and cycle lives.

After operation of EES module array 16 is terminated, control block 32 may control switches 62 to charge EES modules 60 to full capacity for future availability in the event of another failure or sag in power supply 20.

For example, control block 32 may connect all EES modules 60 to the charging power source at the same time, or may stagger the connection to the charging power source to limit the burden on the charging power source. In any case, when EES modules 60 are fully charged, control block 32 may put all EES modules 60 in an idle state (i.e., disconnect EES modules 60 from both power bus 24 and the charging power source) until power from EES module array 16 is again required to drive hoist motor 12.

The incorporation of EES module array 16 into power system 10 and the associated control algorithm thereof provides several advantages and benefits. For example, EES module array 16 provides energy savings by supplementing existing power in power system 10 to account for sudden increases in power requirements (e.g., when hoist motor 12 initially starts up) and to reduce the power drawn from the commercial power utility. Also, EES module array 16 provides extended and uninterrupted operation for power system 10 when power from other power sources is insufficient to drive the load, such as during brownout or blackout conditions. In addition, the incorporation of a plurality of EES modules in EES module array 16 provides inherent redundancy, fault tolerance, and reliability to power system 10, since failure of one EES module can be compensated for by the remaining n-1 functioning EES modules. Furthermore, the control algorithm described simplifies the charging and discharging of the EES modules and provides for an extended and enhanced cycle life of the EES modules.

In summary, the subject invention is directed to driving an elevator hoist motor when power from a power supply is insufficient to drive the hoist motor or when supplemental power is necessary or desired during normal operation. Electrical energy storage (EES) modules are controlled such that at least one EES module drives the hoist motor and at least one EES module charges. Subsequently, the controller changes the at least one EES module that is driving the hoist motor and the at least one EES module that is charging. Thus, power is supplied to the hoist motor to provide uninterrupted service in the event that power from the power supply is insufficient to drive the hoist motor. Consequently, passengers who are in-flight when the power supply fails are transported to their respective destination floors. In addition, the EES modules may be designed to provide sufficient power to drive the elevator hoist motor for an extended period of time, allowing elevator service to continue until the power from the power supply is again sufficient to drive the hoist motor. Furthermore, when the EES modules are employed during normal operation, periods of high power demand are more easily managed, and power drawn from other power sources is reduced.

Although the present invention has been described with reference to examples and preferred embodiments, workers skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the invention.

CLAIMS:

1. A system for driving an elevator hoist motor, the system comprising:

a plurality of electrical energy storage (EES) modules connected between a power supply and the hoist motor; and

a controller operable to control the plurality of EES modules such that at least one EES module drives the hoist motor and at least one EES module charges, wherein the controller changes the at least one EES module that is driving the hoist motor and the at least one EES module that is charging.

2. The system of claim 1, wherein each EES module includes at least one device selected from the group consisting of a supercapacitor and a secondary battery.

3. The system of claim 2, wherein the secondary battery is selected from the group consisting of nickel-cadmium (NiCd), lead acid, nickel-metal hydride (NiMH), lithium ion (Li-ion), lithium ion polymer (Li-Poly), vanadium flow, zinc-bromine flow, and sodium-sulfur batteries.

4. The system of claim 2, wherein the supercapacitor is selected from the group consisting of symmetric and asymmetric supercapacitors.

5. The system of claim 1, wherein the at least one EES charging module recharges from a source selected from the group consisting of the power supply, regenerated power from the hoist motor, and another EES module.

6. The system of claim 1, wherein the controller changes the at least one EES module that is driving the hoist motor and the at least one EES module that is charging at programmed time intervals.

7. The system of claim 1, wherein the controller changes the at least one EES module that is driving the hoist motor and the at least one EES module that is charging based on sensed voltages and current flow in the at least one EES module that drives the hoist motor.

8. The system of claim 1, wherein the controller activates the plurality of EES modules when power from the power supply is insufficient to drive the hoist motor.

9. The system of claim 8, wherein the controller changes the at least one EES module that is driving the hoist motor and the at least one EES module that is charging among the plurality of EES modules until all dispatch requests for the elevator are completed.

10. The system of claim 1, wherein the controller activates the plurality of EES modules during periods of peak power demand in the system.

11. A method for driving a load from a plurality of electrical energy storage (EES) modules, the method comprising:

driving the load from a first group that includes at least one EES module;

charging a second group from a power source, the second group including at least one EES module; and

changing the EES modules that comprise the first group and the second group.

12. The method of claim 11, wherein each EES module includes at least one device selected from the group consisting of a supercapacitor and a secondary battery.

13. The method of claim 11, wherein the power source is selected from the group consisting of a utility power supply, regenerated power from the hoist motor, power from another EES module, and a back-up power supply.

14. The method of claim 11, wherein the driving step comprises connecting the EES modules to the load with a first polarity.

15. The method of claim 14, wherein the charging step comprises connecting the EES modules to the power source with a second polarity opposite the first polarity.

16. A system for driving a load, the system comprising:

an array of electrical energy storage (EES) modules; and a controller for controlling the array to drive the load with a first EES set that includes at least one EES module, and to charge from a charging power source a second EES set that includes at least one EES module, wherein the controller changes the EES modules that comprise the first EES set and the second EES set.

17. The system of claim 16, wherein each EES module includes at least one device selected from the group consisting of a supercapacitor and a secondary battery.

18. The system of claim 17, wherein the secondary battery is selected from the group consisting of nickel-cadmium (NiCd), lead acid, nickel-metal hydride (NiMH), lithium ion (Li-ion), lithium ion polymer (Li-Poly), vanadium flow, zinc-bromine flow, and sodium-sulfur batteries.

19. The system of claim 17, wherein the supercapacitor is selected from the group consisting of symmetric and asymmetric supercapacitors.

20. The system of claim 16, wherein EES modules that are not included in the first EES set or the second EES set are inactive.

21. The system of claim 16, wherein the controller changes the EES modules that comprise the first EES set and the second EES set at programmed time intervals.

22. The system of claim 16, wherein the controller changes the EES modules that comprise the first EES set and the second EES set based on sensed voltages and current flow in the first EES set.

23. The system of claim 16, wherein the load comprises at least one elevator hoist motor.

24. The system of claim 16, wherein the charging power source comprises at least one elevator hoist motor.

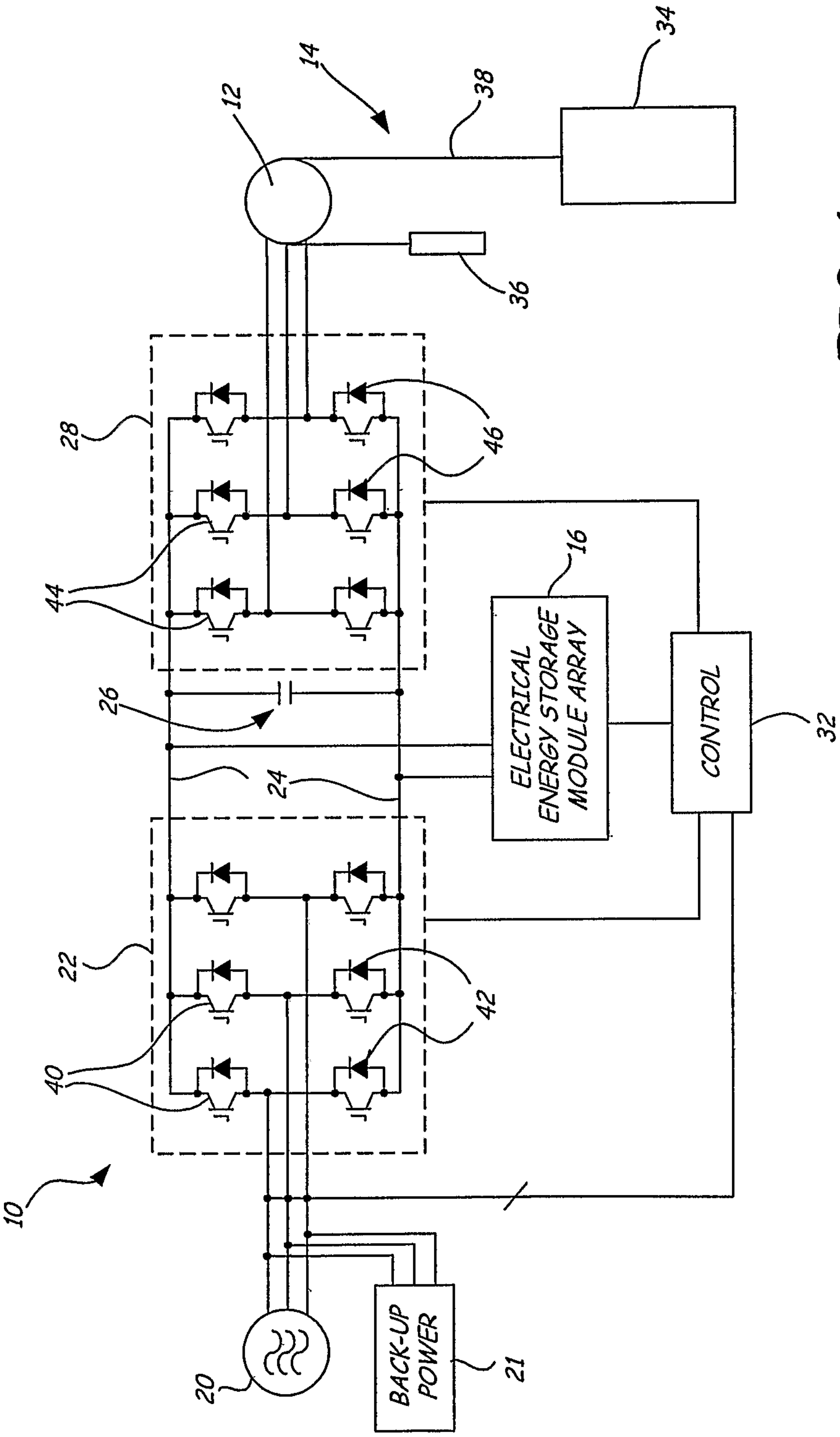
ELECTRICAL ENERGY STORAGE MODULE ARRAY
CONTROL
BACK-UP POWER
10
12
14
16
20
21
22
24
26
28
32
34
36
38
40
42
44
46

FIG. 1

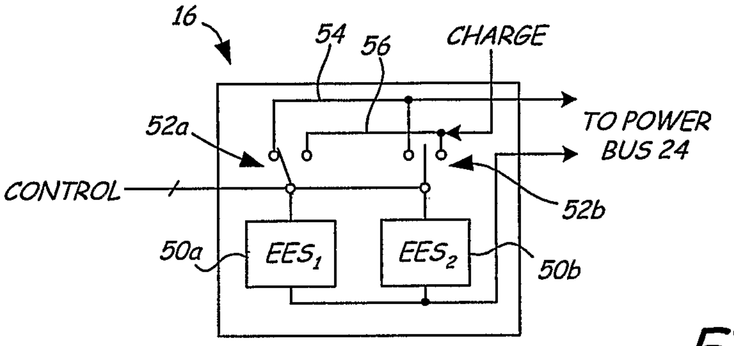

FIG. 2A

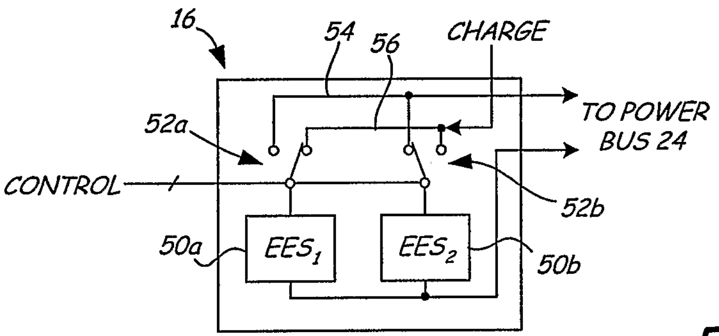

FIG. 2B

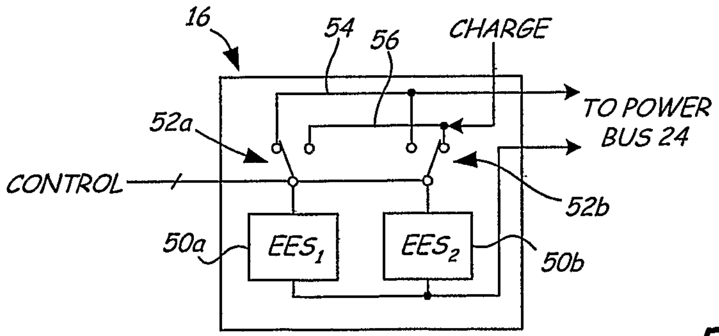

FIG. 2C

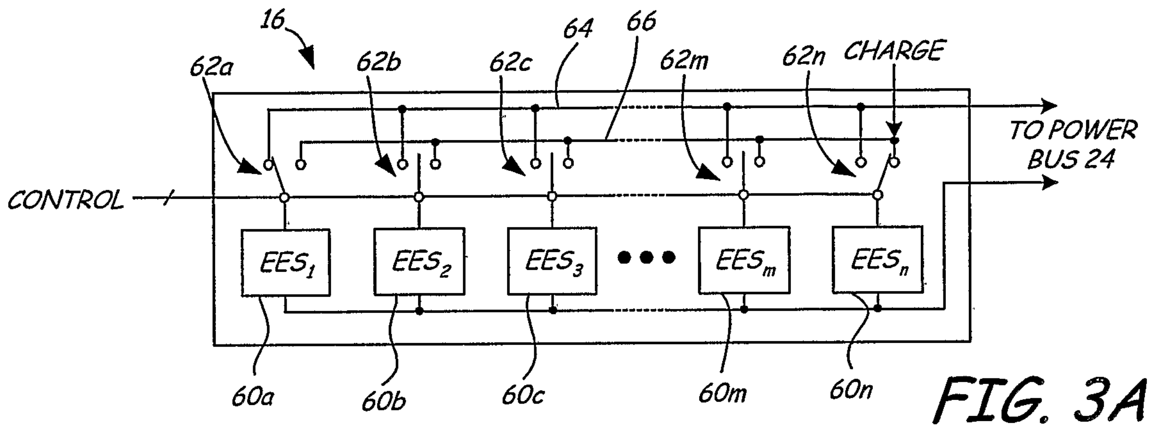
16
62a
62b
62c
64
66
62m
62n
CHARGE
TO POWER BUS 24
CONTROL
EES1
EES2
EES3
EESm
EESn
60a
60b
60c
60m
60n

FIG. 3A

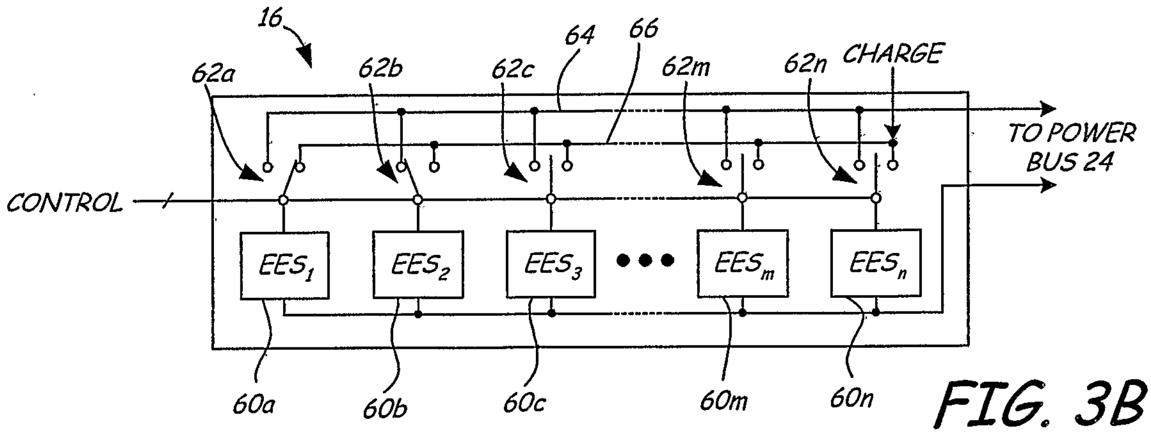
16
62a
62b
62c
64
66
62m
62n
CHARGE
TO POWER BUS 24
CONTROL
EES1
EES2
EES3
EESm
EESn
60a
60b
60c
60m
60n

FIG. 3B

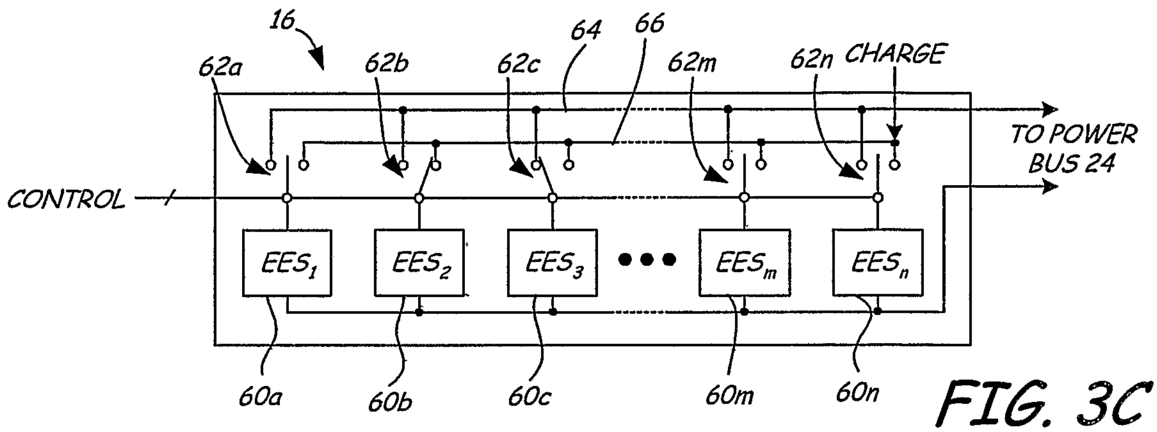
16
62a
62b
62c
64
66
62m
62n
CHARGE
TO POWER
BUS 24
CONTROL
EES1
EES2
EES3
EESm
EESn
60a
60b
60c
60m
60n

FIG. 3C

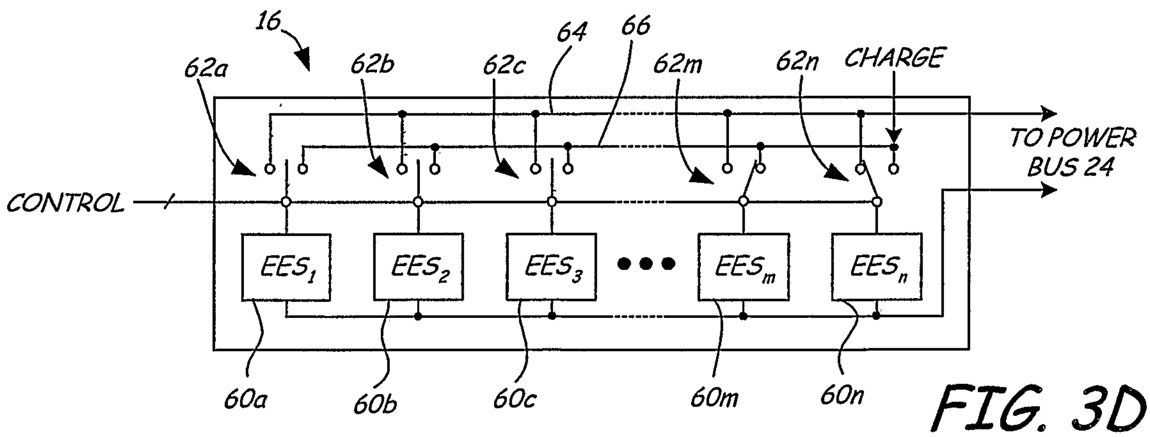
16
62a
62b
62c
64
66
62m
62n
CHARGE
TO POWER
BUS 24
CONTROL
EES1
EES2
EES3
EESm
EESn
60a
60b
60c
60m
60n

FIG. 3D

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US06/23357

A. CLASSIFICATION OF SUBJECT MATTER
IPC: **B66B 1/06**(2006.01)

USPC: 187/290
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 187/290,296,297,247

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 6732838 B1 (OKADA et al) 11 May 2004 (11.05.2004), see entire document.	1,5-8,10,11,13-16,20-24 ----------- 2-4,12,17-19
Y	US 6938733 B2 (EILINGER) 06 September 2005 (06.09.2005), see figures 2,3.	2-4,12,17-19
A	US 5896948 A (SUUR-ASKOLA et al) 27 April 1999 (27.04.1999), see entire document.	1-24

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 October 2006 (19.10.2006)	22 NOV 2006

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