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(54) **UTILITY-SCALE LITHIUM-ION BATTERY TRANSPORTERS**

(71) Applicant: **NOMAD TRANSPORTABLE POWER SYSTEMS, INC.**, Waterbury, VT (US)

(72) Inventors: **Jonathan Edward Bellows**, Waterbury, VT (US); **Gregg Richard Noble**, Saxtons River, VT (US); **Alex David Perkins**, North Ferrisburgh, VT (US); **Lindsay Edward Gorrill**, Coeur d'Alene, ID (US); **Paul Brant Coombs**, St. John's (CA); **Nan Wu**, St. John's (CA); **Jason Jean Martin**, Coeur d'Alene, ID (US); **Mark Williams Hagedorn**, North Plains, OR (US)

(73) Assignee: **NOMAD TRANSPORTABLE POWER SYSTEMS, INC.**, Waterbury, VT (US)

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(52) **U.S. Cl.**
CPC ***B60G 11/56*** (2013.01); ***B62D 63/08*** (2013.01); ***H01M 10/0525*** (2013.01);
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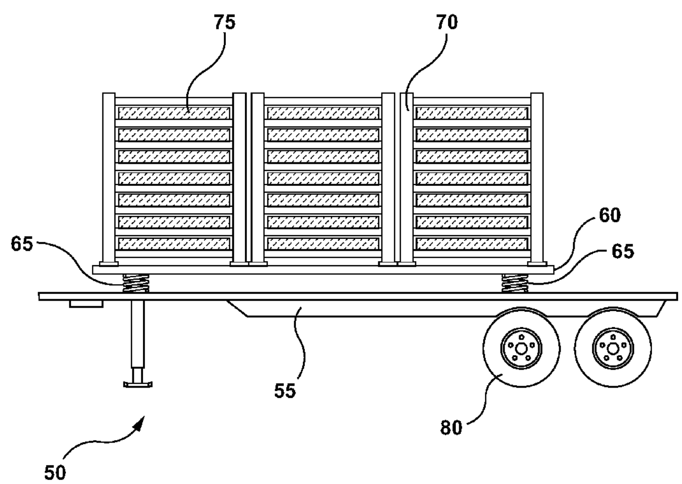
Primary Examiner — Paul N Dickson
Assistant Examiner — Matthew D Lee
(74) *Attorney, Agent, or Firm* — Perry + Currier Inc.

(57) **ABSTRACT**

An example of an apparatus to transport utility-scale lithium-ion batteries in a racked and operational state. The apparatus includes a base and an isolation platform. In addition, the apparatus includes an isolator mounted on the base to support the isolation platform. The isolator is to

(Continued)



dampen forces exerted on the isolation platform from the base. Furthermore, the apparatus includes a rack mounted onto the isolation platform. The rack is to secure a plurality of lithium-ion batteries to store energy at a utility-scale to be provided to a power distribution network. The plurality of lithium-ion batteries is racked in an operational state during transportation.

20 Claims, 9 Drawing Sheets

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H01M 50/204	(2021.01)
H01M 50/24	(2021.01)
H01M 50/249	(2021.01)

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(58) **Field of Classification Search**
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See application file for complete search history.

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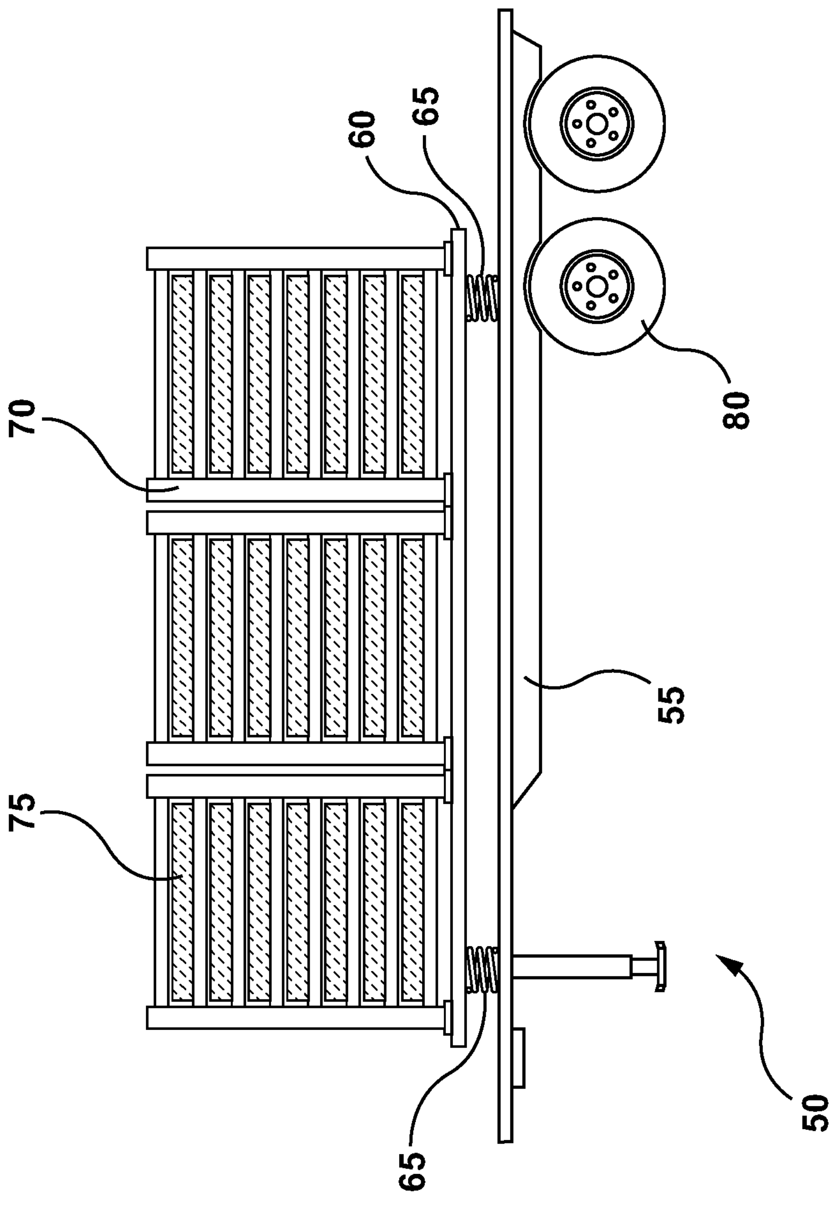

FIG. 1

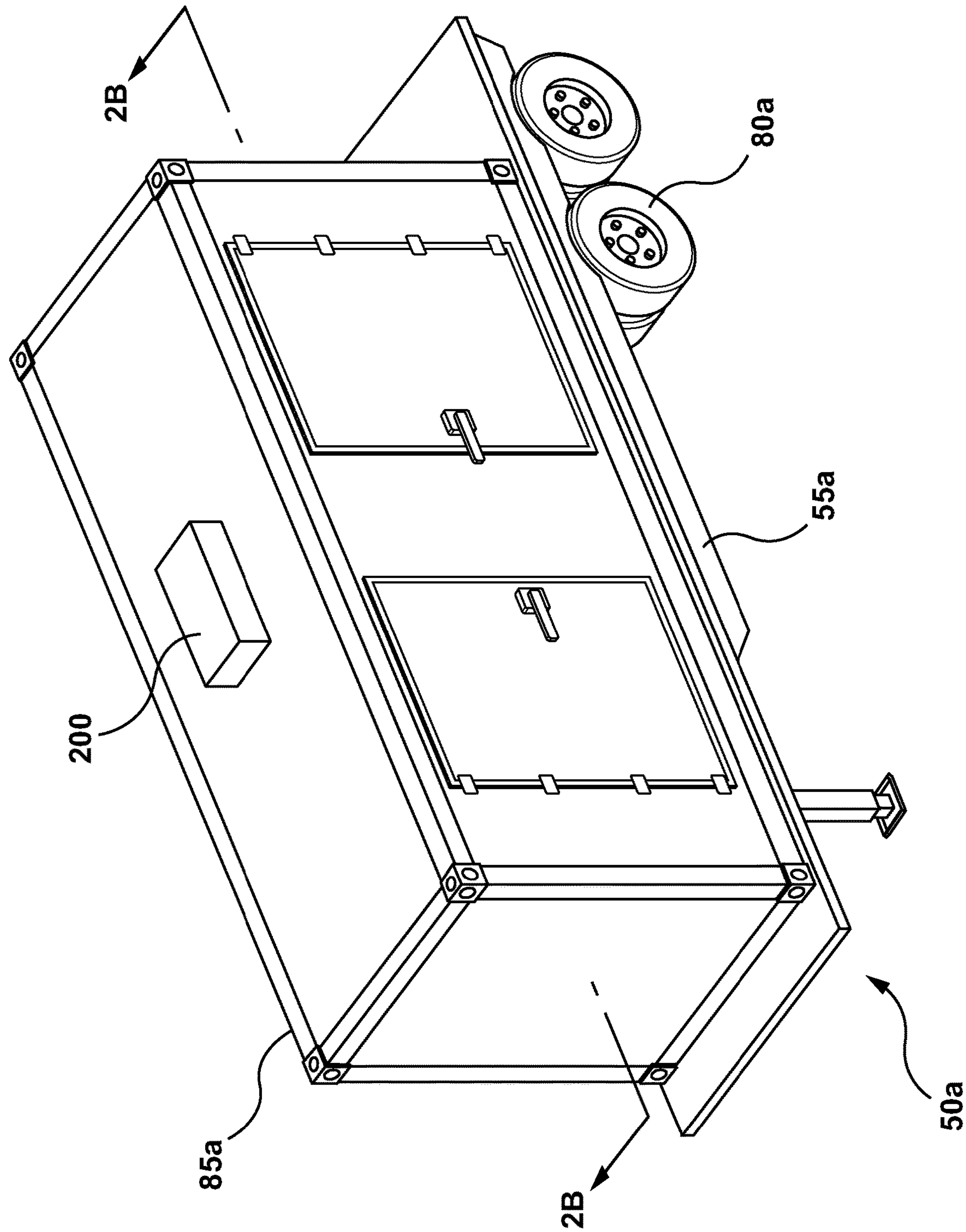

FIG. 2A

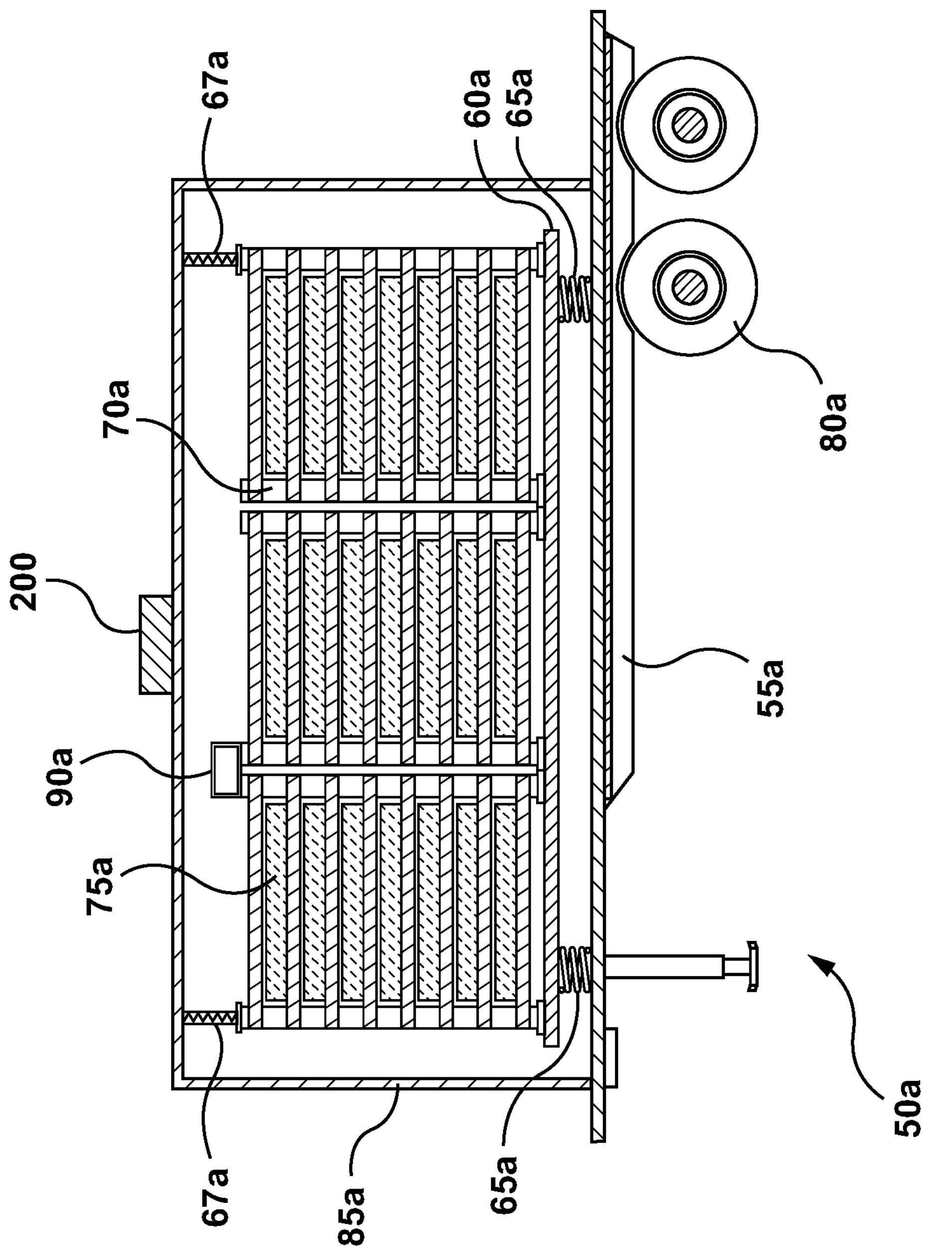

FIG. 2B

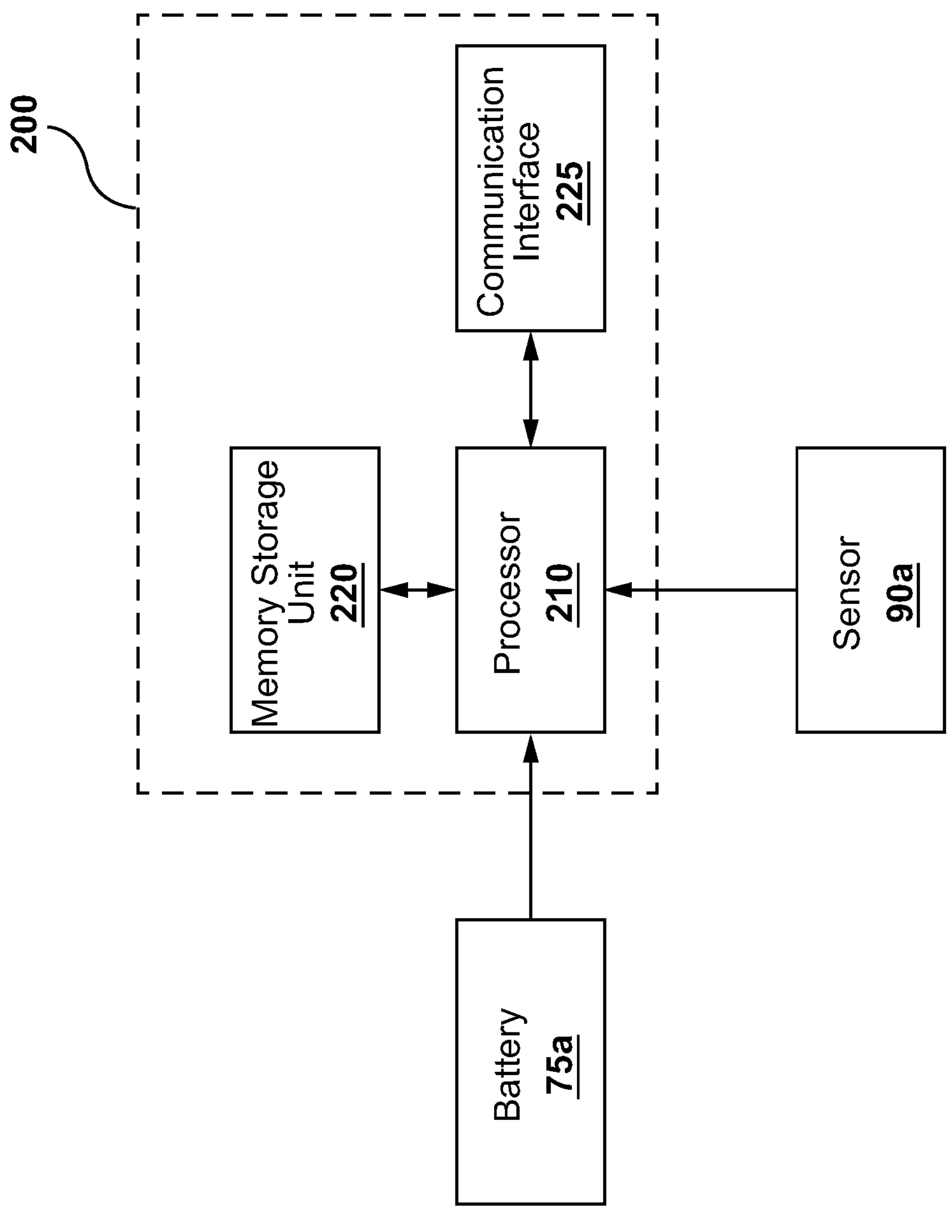
200
Communication Interface 225
Memory Storage Unit 220
Processor 210
Sensor 90a
Battery 75a

FIG. 3

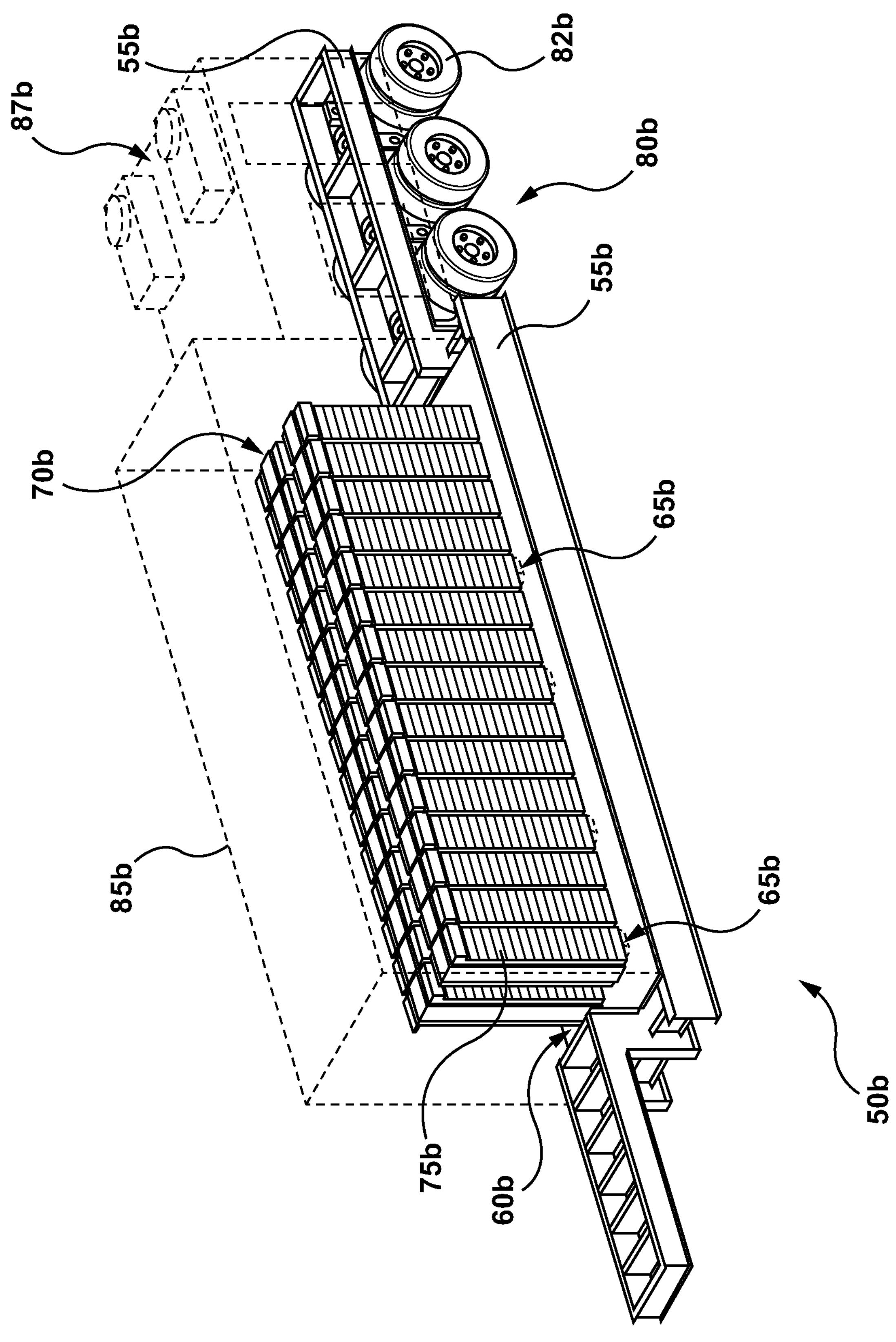

FIG. 4A

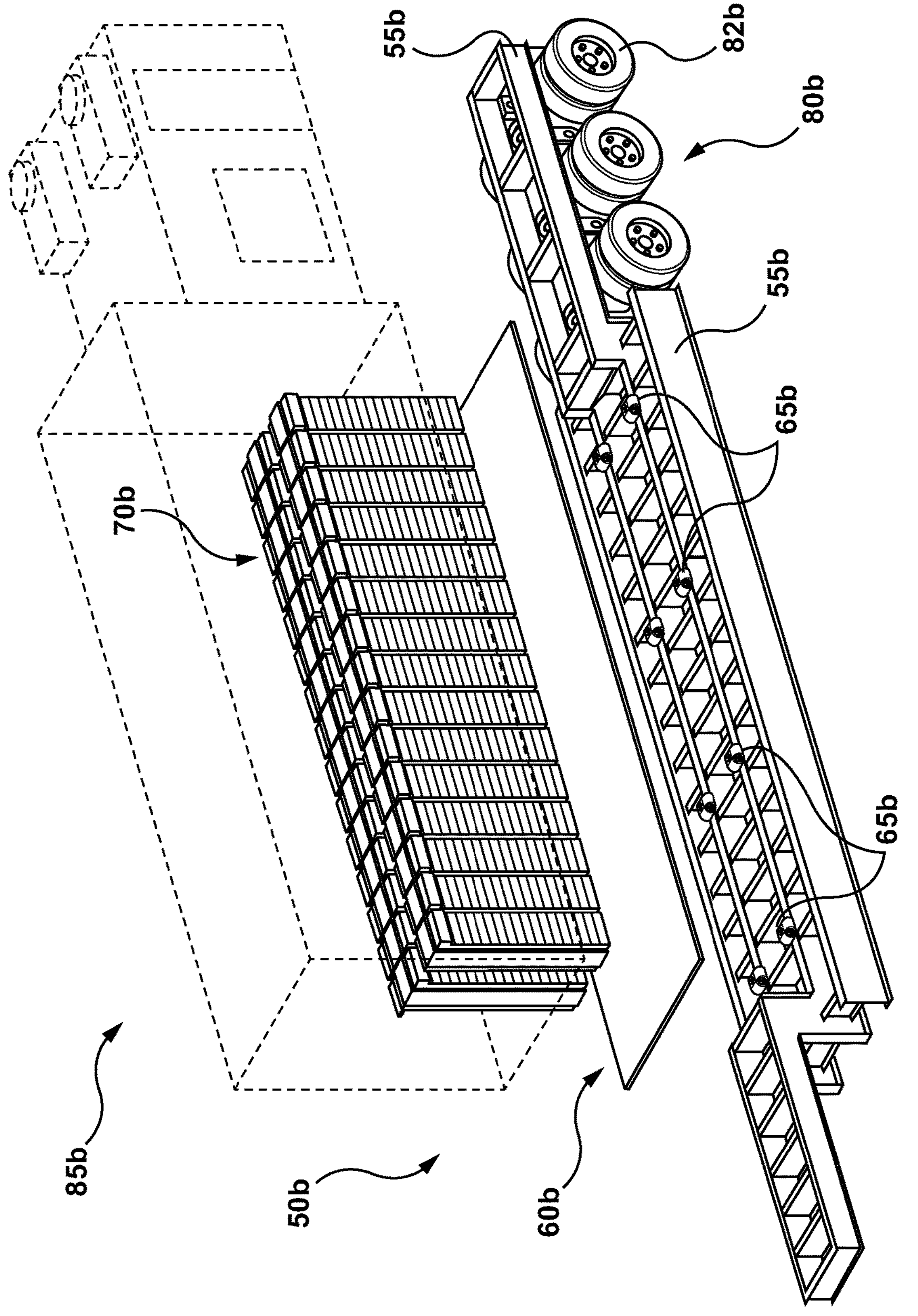

FIG. 4B

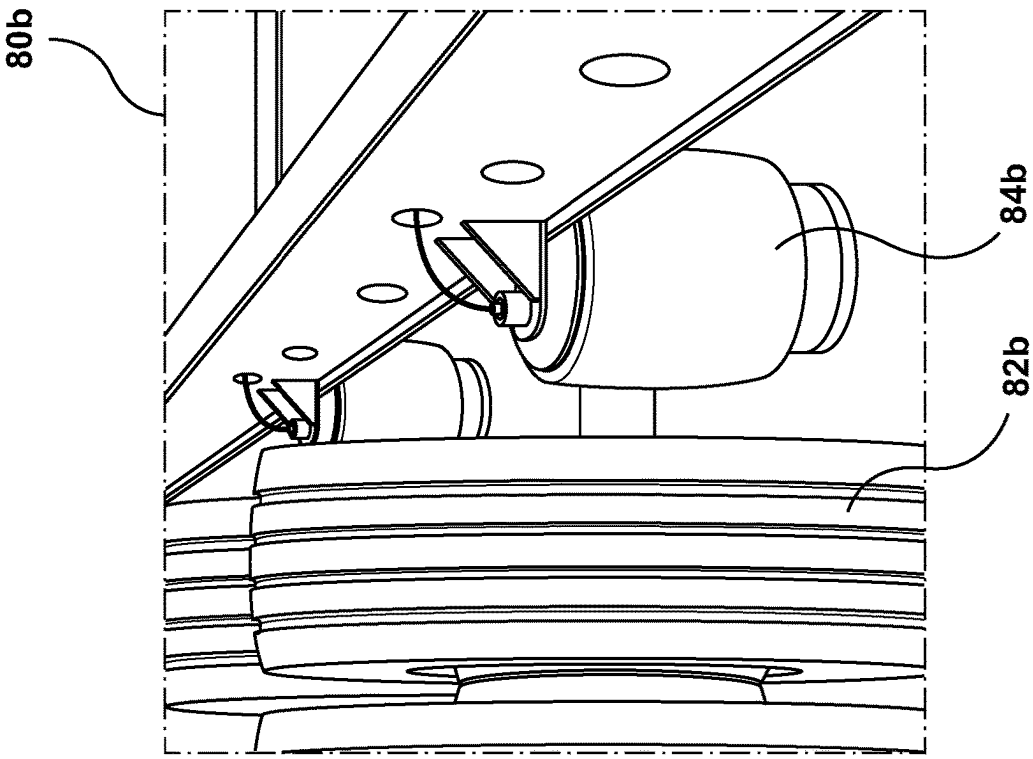

FIG. 4D

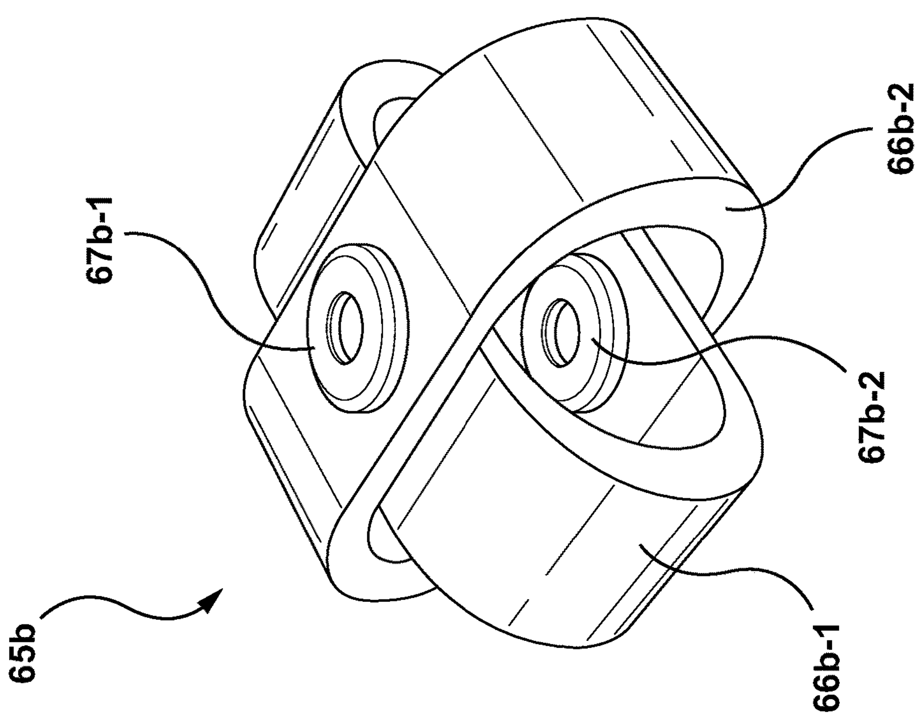

FIG. 4C

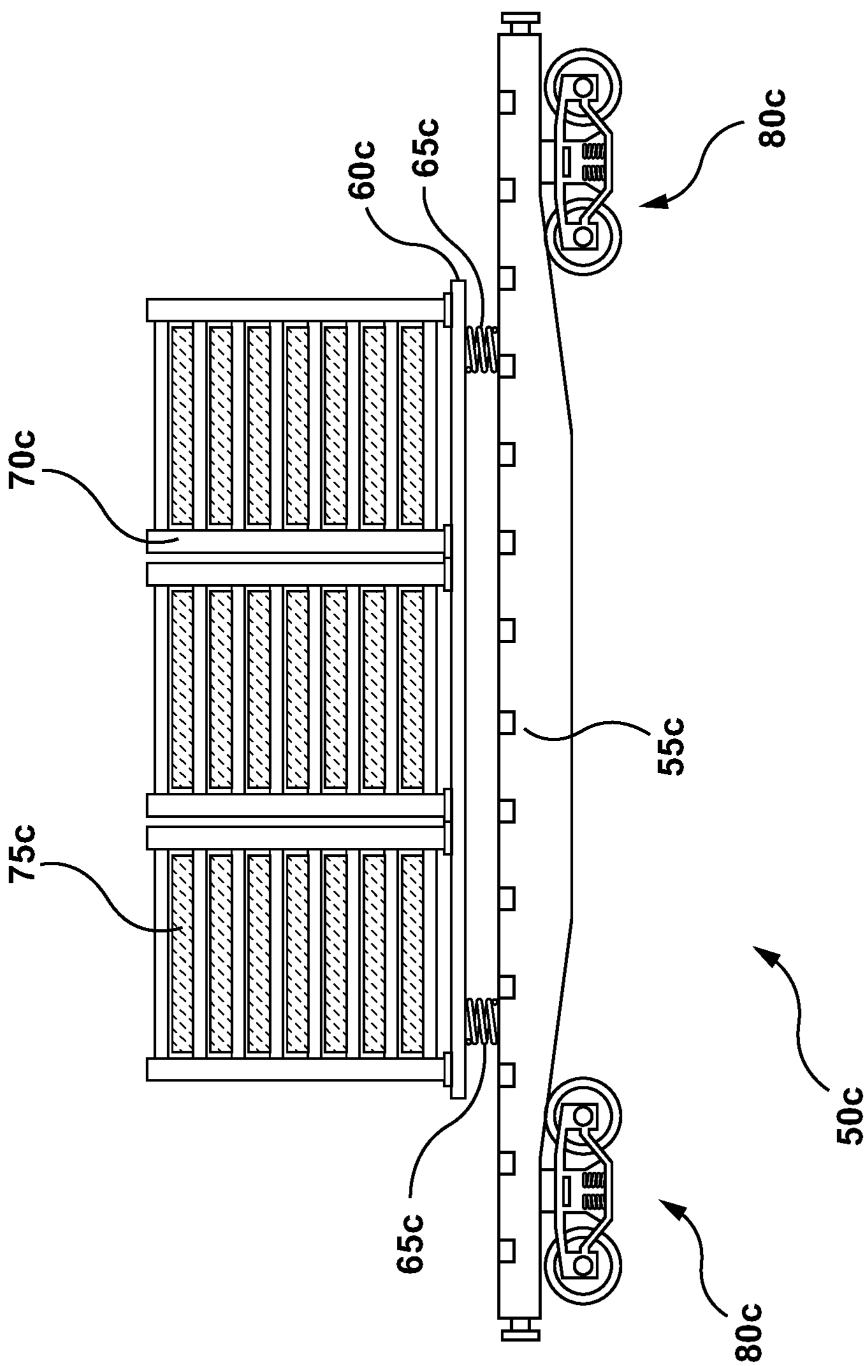

FIG. 5

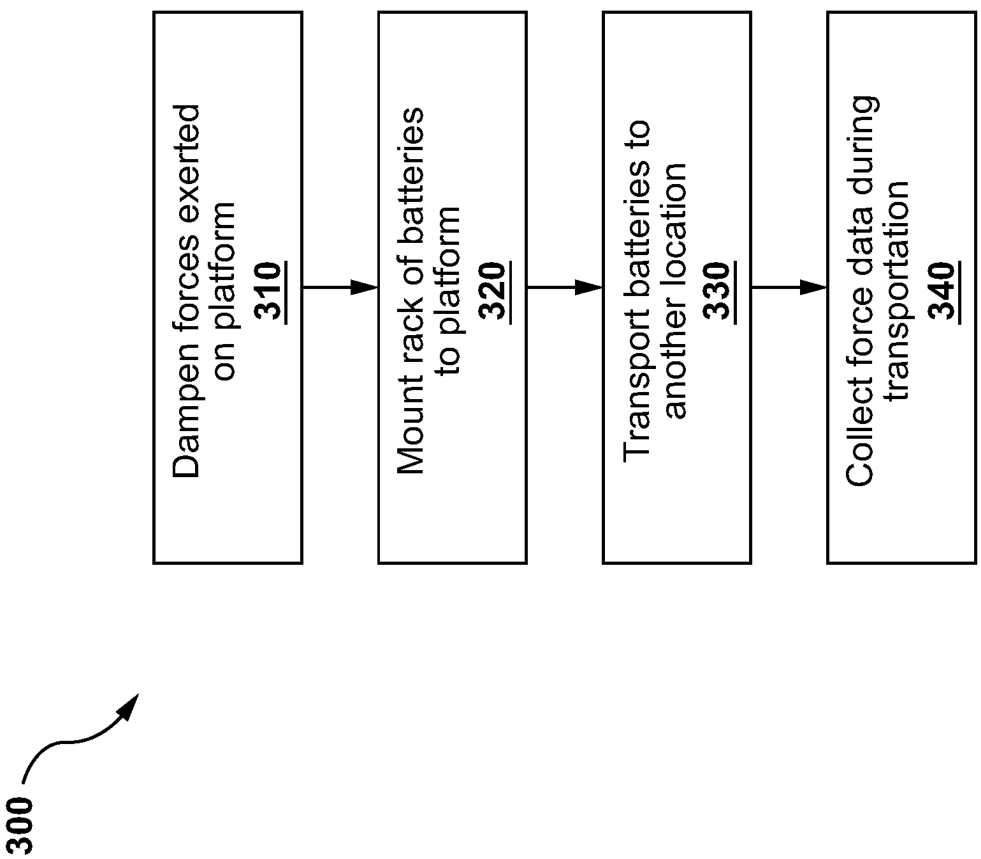
300
Dampen forces exerted on platform
310
Mount rack of batteries to platform
320
Transport batteries to another location
330
Collect force data during transportation
340

FIG. 6

UTILITY-SCALE LITHIUM-ION BATTERY TRANSPORTERS

CROSS-REFERENCE TO RELATED APPLICATION

This application is the National Stage filing under 35 U.S.C. 371 of International Application No. PCT/US2022/016620, filed Feb. 16, 2022, which claims priority to and the benefit of U.S. Provisional Patent Application No. 63/150,155, filed Feb. 17, 2021, which are incorporated by reference in their entireties.

BACKGROUND

Electricity and the delivery of electricity plays a major role in industrial development, economic development, and for personal use in daily life. Electricity may be generated to supply a power system or power grid. The demand of the power grid may fluctuate through time, in short intervals such as throughout the day, or over longer periods of time such as seasons of the year. For example, air conditioning energy loads may increase the amount of demand for electricity for the grid during the summer months, while this demand may vanish in the winter months. When the demand for electricity increases, the supply of electricity may not be able to be increased beyond an infrastructure limit. Accordingly, energy sources, such as generating stations are typically designed to provide the peak electricity demanded. When the demand exceeds this amount, the power system may not be able to maintain the specified power requirements of the loads resulting in brownouts, blackouts, or increases in power costs as the supplier adjusts and purchases electricity from the active, open market.

Energy storage systems may be used at the utility-scale to balance electricity supply and demand. In particular, lithium-ion batteries provide a high energy efficiency, long cycle life, and high energy density storage platform. Due to the weight and safety issues associated with moving charged utility-scale lithium-ion batteries, they are generally shipped in an uncharged and non-racked state to a location to be installed and charged for use. Accordingly, these utility-scale energy storage systems are generally at a fixed location and involve significant assembly and disassembly processes when the batteries are moved from one location to another. In practice, this generally means that lithium-ion batteries are only deployable at a specific location connected to one point on an electric grid where they remain for an extended period of time, typically ten to twenty years.

SUMMARY

In accordance with an aspect of the invention, an apparatus is provided. The apparatus includes a base and an isolation platform. The apparatus further includes an isolator mounted on the base to support the isolation platform, wherein the isolator is to dampen forces exerted on the isolation platform from the base. In addition, the apparatus includes a rack mounted onto the isolation platform. The rack is to secure a plurality of lithium-ion batteries to store energy at a utility-scale to be provided to a power distribution network. The plurality of lithium-ion batteries is to be racked in an operational state during transportation.

The base includes a transportation system. In particular, the base may be a trailer to be towed by a tractor.

The apparatus may further include an enclosure to protect the plurality of lithium-ion batteries from weather elements.

In addition, the apparatus may include a dampener to connect a top portion of the rack to a ceiling of the enclosure. The dampener may secure the rack and to reduce motion of the rack relative to the base.

The apparatus may also include a shock sensor to collect force data of the forces exerted on the plurality of lithium-ion batteries. The apparatus may include a monitoring system to transmit the force data to an operator during transportation. The monitoring system may include a memory storage unit to store the force data.

The apparatus may include a weather sensor or a weather sensor array to collect weather data associated with conditions to which the plurality of lithium-ion batteries is subjected.

In accordance with another aspect of the invention, another apparatus is provided. The apparatus includes a trailer. The apparatus further includes a pneumatic suspension system disposed on the trailer to reduce road vibrations at a top surface of the trailer during transport. In addition, the apparatus includes a plurality of isolator springs mounted on the top surface of the trailer. Furthermore, the apparatus includes an isolation platform supported by the plurality of isolator springs. Each isolator spring is to reduce trailer vibrations on the isolation platform.

In accordance with another aspect of the invention, a method is provided. The method involves dampening forces exerted on an isolation platform with a plurality of isolators. The method further involves mounting a rack of lithium-ion batteries to store energy at a utility-scale to the isolation platform. In addition, the method involves transporting the lithium-ion batteries from a first location to a second location. The plurality of lithium-ion batteries is to be racked in an operational state during transportation. Furthermore, the method involves collecting force data of the forces exerted on the plurality of lithium-ion batteries during transportation.

BRIEF DESCRIPTION OF THE DRAWINGS

Reference will now be made, by way of example only, to the accompanying drawings in which:

FIG. **1** is a side view representation of an example of an apparatus to transport utility-scale lithium-ion batteries in a racked and operational state to different locations;

FIG. **2**A is a perspective view representation of an example of an apparatus with an enclosure to transport utility-scale lithium-ion batteries in a racked and operational state to different locations;

FIG. **2**B is a cross sectional view of the example of the apparatus to transport utility-scale lithium-ion batteries shown in FIG. **2**A along the plan **2**B-**2**B,

FIG. **3** is a schematic representation of an example of a monitoring system;

FIG. **4**A is a perspective view representation of another example of an apparatus to transport utility-scale lithium-ion batteries in a racked and operational state to different locations;

FIG. **4**B is an exploded view of the example of an apparatus to transport utility-scale lithium-ion batteries shown in FIG. **4**A;

FIG. **4**C is a view of an example of an isolator spring of the apparatus to transport utility-scale lithium-ion batteries shown in FIG. **4**A;

FIG. **4**D is a view of an example of a pneumatic suspension system of the apparatus to transport utility-scale lithium-ion batteries shown in FIG. **4**A;

FIG. **5** is a side view representation of another example of an apparatus to transport utility-scale lithium-ion batteries in a racked and operational state to different locations; and

FIG. **6** is a flowchart of an example of a method of transporting utility-scale lithium-ion batteries in a racked and operational state.

DETAILED DESCRIPTION

The demand for electricity may often fluctuate to create imbalances between power generation and power consumption. In particular, instantaneous demand for electrical energy is often unpredictable from day to day and may depend on various factors such as temperature, industrial manufacturing changes, and seasonal variations. The variations may result in challenges to the power distribution network in terms of electricity generation and distribution. To address this issue, a utility-scale energy storage system may be installed in the power distribution network, such as a power grid, to convert and store electricity from an energy source, such as a generation station, and to subsequently convert it back into electrical energy to be re-supplied into the power distribution network. In some examples, additional electrical energy above the generation rate of power distribution network during peak demand periods. During these periods, an energy storage system that has been pre-charged with power may supplement the electricity supplied in the power distribution network.

Although batteries may be used to provide portable electrical energy in portable energy storage system on small scales such as to power electric cars and other apparatus, such as portable equipment, at a remote work site, utility-scale energy storage systems, such as systems with a capacity greater than about 200 kilowatt-hours are typically stationary by design. In particular, utility-scale energy storage systems cannot be transported safely while in a charged or operational state due to the large amount of energy stored and weight of the batteries. An accident during transportation may result in a catastrophic event. Accordingly, the batteries for utility-scale energy storage solutions are generally transported in a safer non-operational state, or de-racked state. Therefore, the energy storage system is to be installed or racked up at the final location to be installed in a fixed facility. Prior to moving the batteries of the utility-scale energy storage system, the batteries are to be de-racked and converted into a non-operational state for safe transportation.

An apparatus is provided to transport utility-scale lithium-ion batteries in a racked and operational state to different locations that may experience temporarily large swings in electricity consumption. The utility-scale lithium-ion batteries may be used to provide energy storage to supplement electricity generation during periods of peak electricity usage on a power grid and to receive excess energy for storage during periods of low electricity usage on the power grid. The utility-scale lithium-ion batteries may then be moved from one location to another to avoid idling when the utility-scale lithium-ion batteries are not used, such as during prolonged periods of low electricity usage. Accordingly, this allows the utility-scale lithium-ion batteries to be moved and deployed at a new location much faster and to avoid the utility-scale lithium-ion batteries staying in a single location idling when not in use.

Referring to FIG. **1**, a schematic representation of an apparatus to transport utility-scale lithium-ion batteries in a racked and operational state to different locations is generally shown at **50**. The apparatus **50** may include additional components, such as various additional interfaces and/or input/output devices such as additional sensors and indicators. In addition, the apparatus **50** may also include electronics and other components to connect to a power distribution network via a docking station. In the present example, the apparatus includes a base **55**, an isolation platform **60**, an isolator **65**, and a rack **70** to secure a plurality of lithium-ion batteries **75** thereon.

The base **55** is to support the components of the apparatus **50**. In the present example, the lithium-ion batteries may weigh over about 30,000 kilograms. Accordingly, the base **55** is to be able to mechanically support the mass of the batteries. The materials from which the base **55** is constructed is not particularly limited. In the present example, the base **55** is constructed from a plurality of steel beams to form a flatbed trailer. Accordingly, the base **55** may further include a transportation system **80**, such as wheels on an axle. The trailer may then be towed by a tractor from one location to another location. It is to be appreciate by a person of skill with the benefit of this description that the base **55** may include additional components typically found on trailers. Furthermore, the transportation system **80** is not particularly limited and may include mechanisms for other modes of transportation such as rail as a railcar, or water as a barge.

The isolation platform **60** is to be mounted onto the base **55** with an isolator **65**. In the present example, the isolator **65** is securely mounted to the base **55** of the isolation platform **60** is to be supported above the base **55** by the isolator **65**. The isolator **65** is to dampen forces exerted on the isolation platform **60**, such as vibrations and acceleration forces associated with road travel that are applied to the base **55**.

The isolator **65** is not particularly limited and may be any device capable of supporting the weight of the isolation platform **60** the components, such as the rack **70** and the plurality of lithium-ion batteries **75**, mounted thereon. In the present example, the isolator **65** is a coil spring suspension system. In other examples, the isolator **65** may be a leaf-spring system or a gel damper pad, or a hydraulic or pneumatic piston assembly, or various polymers, visco-elastic polymers, visco polymers or simply polymers designed for shock reduction purposes, or a SALT (Shock-Absorbant Liquid) cushion. Furthermore, the number of elements of the isolator **65** used to support the isolation platform **60** is not particularly limited and may depend on the weight of the lithium-ion batteries **75** as well as other components on the isolation platform **60**. Accordingly, although only two elements of the isolator **65** are illustrated in FIG. **1**, more or less may be used.

In the present example, the rack **70** is mounted onto the isolation platform **60** to secure the lithium-ion batteries **75**. In the present example, the lithium-ion batteries **75** collectively provide the capacity to store energy at a utility-scale, such as with a capacity greater than about 200 kilowatt-hours, for use with a power distribution network. The power distribution network to which the apparatus connects is not particularly limited to any type of network as multiple applications are contemplated. For example, the power distribution network may by a public utility power grid, a private system used to power a factory or group of small buildings to supplement a public power grid, or a closed system to provide electricity to a construction site, a mining site, a disaster recovery zone, or military forward operating base or other remote location far from a public power grid.

The manner by which the rack **70** is mounted onto the isolation platform **60** is not particularly limited. For example, the rack **70** may be built into the isolation platform **60** forming a unitary body. In other examples, the rack **70** may be welded onto the isolation platform **60**. In further examples, the rack **70** may be mounted using other methods such as fasteners, straps and bolts. Similarly, the manner by which the lithium-ion batteries **75** are secured to the rack **70** is not limited and may include welding or fastening to connection points disposed on the rack **70**.

By mounting the lithium-ion batteries **75** onto the rack **70** and isolation platform **60**, the lithium-ion batteries **75** may be maintained in a racked position and in an operational state during transportation between docking stations. In particular, the lithium-ion batteries **75** may be disconnected from a docking station in a charged state at one location and transported to another location in the charge state to be simply plugged in and operated without any further initiation processes. Without addressing potential damage to the lithium-ion batteries **75** that may be caused by forces from the road, such as vibrations and acceleration forces, transporting the lithium-ion batteries **75** which have utility-scale capacities in a charged state is considered dangerous.

Referring to FIGS. **2**A and **2**B, a representation of another apparatus **50***a* to transport utility-scale lithium-ion batteries in a racked and operational state to different locations is generally shown. Like components of the apparatus **50***a* bear like reference to their counterparts in the apparatus **50**, except followed by the suffix "a". In the present example, the apparatus **50***a* includes a base **55***a*, an isolation platform **60***a*, an isolator **65***a*, a dampener **67***a*, a rack **70***a* to secure a plurality of lithium-ion batteries **75***a*, an enclosure **85***a*, and a sensor **90***a*.

In the present example, the base **55***a* is substantially similar to the base **55**. In particular, the base **55***a* is to support the weight of the lithium-ion batteries **75***a*, which may be over about 30,000 kilograms in some implementations. Furthermore, the base **55***a* also includes a transportation system **80***a* to function as a trailer to be towed by a tractor between locations in the present example.

The apparatus **50***a* further includes an enclosure **85***a* to protect sensitive equipment, such as the lithium-ion batteries **75***a*. In particular, the enclosure **85***a* may shield the lithium-ion batteries **75***a* from weather elements such as wind, rain, snow, or sunlight during operation. In addition, the enclosure **85***a* may protect the contents during transportation from weather elements as well as road hazards, such as rocks and other debris.

The enclosure **85***a* is not particularly limited and may be varied. In particular, the enclosure **85***a* may be modified based on the expected locations where the apparatus **50***a* is to be deployed and the anticipated weather conditions for that location. For example, the enclosure **85***a* may include thermal insulation properties to protect against large temperature changes. To complement the thermal insulation, the apparatus may also include an additional heating, air conditioning, and ventilation systems to control the conditions inside the enclosure **85***a*. By controlling the conditions inside the enclosure **85***a*, the performance of the lithium-ion batteries **75***a* may be improved as well as the lifetime of the lithium-ion batteries **75***a*. In other examples, the enclosure **85***a* may be include fireproof panels, deflagration panels, or be reinforced to withstand an explosion if a battery fails. It will be understood that by containing fire during a battery failure, the safety of the apparatus **50***a* is improved. The safety may be further improved by installing a fire suppression system, emergency ventilation systems, such as with automated dampers, and a traditional fire suppression system, such as a dry deluge standpipe leading to a sprinkler system.

In the present example, the apparatus **50***a* further includes a dampener **67***a* to connect the top portion of the rack **70***a* to the ceiling of the enclosure **85***a*. The ceiling mounted dampener **67***a* is to secure the top of the rack **70***a* to further reduce motion of the rack **70***a* relative to the base **55***a*. By reducing the relative motion, the forces and vibrations associated with road travel and experienced by the lithium-ion batteries **75***a* may be further suppressed.

It is to be appreciated by a person of skill with the benefit of this description that the dampener **67***a* may be modified in other examples. For example, the dampener **67***a* may not mounted onto a sidewall of the enclosure **85***a* instead of the ceiling. In other examples, the upper portion of the rack **70***a* may also be secured to other portions of the enclosure **85***a* or structures within the enclosure **85***a* to reduce vibrational and acceleration forces.

The apparatus **50***a* also includes a sensor **90***a*. The sensor **90***a* is not particularly limited and may be any type of sensor to collect data that may be used to determine a status of the lithium-ion batteries **75***a*, or to be used as a predictor of the lifetime of the lithium-ion batteries **75***a*. Furthermore, the location of the sensor **90***a* is not limited and may be varied depending on the type of sensor. For example, the sensor **90***a* may be disposed on the exterior of the enclosure **85***a* or on another part.

As an example, the sensor **90***a* may be a shock sensor to collect force data associate of the forces exerted on the plurality of lithium-ion batteries **75***a*. In this example, the sensor **90***a* is to measure movements. The manner by which movement is measured is not limited and may include a set-point or proximity switch. In other examples, movements may also be measured or inferred from an accelerometer. By placing such as sensor **90***a* on top of the rack **70***a*, the sensitivity to movement may be increased if the entire rack **70***a* were to sway during transportation. In other examples, the sensor **90***a* may be placed on the dampeners **67***a*, the wall or ceiling of the enclosure **85***a*, within the isolators **65***a*, or on the isolation platform.

In another example, the sensor **90***a* may be an environmental or weather sensor to deter the climate. For example, the sensor **90***a* may be a pyranometer to measure sunlight, a wind sensor, a barometer, a temperature sensor, and/or a humidity sensor. The sensor **90***a* may also be disposed at a different location, on the apparatus **50***a*, such as on the wall of the enclosure **85***a* to more accurately measure conditions. Furthermore, it is to be appreciated in this example, the sensor **90***a* may be used to collect weather data associated with the conditions in which the apparatus **50***a* is operating or during transportation. Accordingly, the weather data may provide historical data for conditions to which the lithium-ion batteries **75***a* were subjected. It is to be appreciated by a person of skill with the benefit of this description that the historical data may be used to estimate the remaining lifetime of the lithium-ion batteries **75***a*. In other examples, the historical data may also be used to verify proper maintenance of the lithium-ion batteries **75***a* if a warranty claim were to be made or to determine if a leased apparatus **50***a* were abused.

Referring to FIG. **3**, a schematic representation of a monitoring system **200** is shown. In order to assist in the explanation of the monitoring system **200**, it will be assumed that the monitoring system **200** is in communication with the apparatus **50***a*. In the present example, the monitoring system **200** is mounted onto the roof of the enclosure **85***a*.

In the present example, the monitoring system **200** is in communication with the lithium-ion batteries **75***a* and the sensor **90***a*. The manner by which the monitoring system **200** communicates with the lithium-ion batteries **75***a* and the sensor **90***a* is not particularly limited. For example, the monitoring system **200** may communicate via a wired connection. In other examples, the monitoring system **200** may communicate wirelessly, such as with a BLUETOOTH or WIFI connection. It is to be appreciated by a person of skill with the benefit of this description that the apparatus **50***a* may include additional components in communication with the monitoring system **200**. For example, the monitoring system **200** may be in communication with a plurality of additional sensors that may or may not be the same type as well as additional batteries. Furthermore, the following discussion of the monitoring system **200** may lead to a further understanding of the apparatus **50***a* and it components. In the present example, the monitoring system **200** includes a processor **210** in communication with the battery **75***a* and the sensor **90***a*, a memory storage unit **220**, and a communications interface **225**. Furthermore, in other examples, the monitoring system **200** may not be mounted on the enclosure **85***a* and instead be disposed at a separate location. In such an example, the monitoring system **200** may be in communication with multiple apparatuses **50***a* and located at a central monitoring facility.

In the present example, the lithium-ion batteries **75***a* may provide data to the processor **210**. The processor **210** is configured to monitor data from the lithium-ion batteries **75***a*, which may include the charge level and battery health information.

The sensor **90***a* also provides sensor data to the processor **210**. The sensor data received by the processor **210** is not particularly limited and may include data that may provide information to confirm that the battery **75***a* has not experience a force or other condition that is beyond the tolerances of the battery **75***a*. In the present example where the sensor **90***a* is a shock sensor, the sensor **90***a* may be disposed on the rack **70***a* to collect data during transportation. For example, the sensor **90***a* may be an accelerometer to detect the forces exerted on the rack **70***a* which may be inferred to be the forces exerted on the batteries **75***a*. The forces are not particularly limited and may include acceleration forces from starting and stopping as well as acceleration forces from turning or driving over bumps on the road. Accordingly, the sensor **90***a* may be used to monitor these forces and the processor **210** may provide a warning if the battery **75***a* was subjected to a sudden acceleration or deceleration, such as excessive braking or an accident, that exceeds the limits that the battery **75***a*.

As an example, the sensor **90***a* may be a temperature sensor disposed near the battery **75***a* to measure the temperature around the battery **75***a*. The processor **210** may further include a controller to operate a climate control system (not shown) to maintain a constant temperature and humidity within a predetermined operating range. In other examples, a temperature sensor may be used as a safety device to detect a runaway condition to warn a driver, sound an external alarm, or activate an emergency fire suppression system or an emergency ventilation system.

The memory storage unit **220** is to store the data collected by the sensor **215** or information generated by the monitoring system. In particular, the memory storage unit **220** is to generate a log of events and conditions to which the lithium-ion batteries **75***a* was subjected. Continuing with the present example where the sensor **90***a* is a shock sensor, the memory storage unit **220** may store force data collected by the sensor **90***a*. The memory storage unit **220** is not particularly limited. In the present example, the memory storage unit **220** is a non-transitory machine-readable storage medium that may be any electronic, magnetic, optical, or other physical storage device. In other examples, the memory storage unit **220** may be a separate device external from the battery **75***a*, such as an external server in the cloud.

The communications interface **225** is to communicate with an external device to which the data about the battery **75***a* to be transmitted. In the present example, the communications interface **225** may communicate with an external device over a network, which may be a public cellular network to a central location. In this example, the conditions of the battery **75***a* may be monitored at a central location so that if an issue occurs, a service call or replacement unit may be dispatched immediately. In other examples, the communications interface **225** may transmit the data to an external device near the driver or operator such that the driver of the vehicle may monitor the status and conditions the battery **75***a* during transportation. The external device is not limited and may be a smartphone or tablet carried by the driver or operator in some examples. In other examples, the external device may be a panel in the cab of the tractor moving the apparatus **50***a* that is either hardwired to wirelessly connected to the monitoring system **200**. Accordingly, the driver or operator of the tractor moving the apparatus may receive the force data from the sensor **90***a* in real time and adjust driving habits.

In further examples, the sensor **90***a* may be an environmental sensor or sensor array to detect the conditions proximate to the battery **75***a*. In particular, the sensor **90***a* may measure solar radiation via pyranometer, wind speed, barometric pressure, temperature, and humidity. The processor **210** may store this weather data to determine a target charge-discharge schedule to increase performance of the battery **75***a*. For example, if the weather indicates that there will be a high demand for air conditioning, the processor **210** may direct the battery to delay charging until the demand decreases to provide predictive analytics. The predictive analytics may subsequently be used to cycle the battery **75***a* in a more efficient manner.

In addition, the weather data may also be used for system preventative care, emergency planning, or disaster recovery purposes. In the present example, the sensor **90***a* may be able to predict significant storm events and may direct an apparatus **50***a* to pre-charge in anticipations of potential outage periods. In further examples, the processor **210** may be combined with other infrastructure such as a remote dispatcher via the communications interface **225**. Based on information received from a network of apparatuses spread across a region, the processor **210** may provide information to move an apparatus away from a danger or to prepare for extreme conditions by automatically entering into a self-protecting state (pre-charging in advance of a grid outage) when barometric pressures drop suddenly or below predetermined threshold levels or when wind speeds pick up above predetermined threshold wind levels. The processor may also send an alarm such that an administrator is alerted to an extreme condition. Therefore, the sensor **90***a* and the monitoring system may allow for the protection from incoming storms. In particular, when an adverse weather condition is detected, the apparatus may be redeployed safely away from the adverse conditions until the conditions pass.

Referring to FIGS. **4**A, **4**B, **4**C, and **4**D, another apparatus **50***b* and detailed views of portions of the apparatus **50***b* to transport utility-scale lithium-ion batteries in a racked and operational state to different locations is generally shown.

Like components of the apparatus **50***b* bear like reference to their counterparts in the apparatus **50***a*, except followed by the suffix "b". In the present example, the apparatus **50***b* includes a trailer **55***b*, an isolation platform **60***b*, a plurality of isolator springs **65***b*, and a pneumatic suspension system **84***b*. In the present example, the apparatus **50***b* further includes an enclosure **85***b* which may be omitted in other examples where the load carried by the apparatus **50***b* is not substantially affected by weather elements.

Furthermore, the apparatus **50***b* may further include an equipment room **87***b* to house control systems, electrical components, and mechanical components. For example, the control room **87***b* may include power conversion and distribution systems with inverters to convert direct current power from the batteries to alternating current for a power distribution network as well as converters to convert alternating current to direct current to charge the batteries. In addition, the equipment room **87***b* may include a heating, air conditioning and ventilation system to control the environment within the enclosure **85***b*. In the present example, the equipment room **87***b* may include systems to control the humidity within the enclosure **85***b*.

The trailer **55***b* is to support the components to be transported by the apparatus **50***b*. In the present example, the apparatus **50***b* is to transport a plurality of lithium-ion batteries **75***b* mounted on racks **70***b*. The lithium-ion batteries **75***b* and the racks **70***b* may be replaced with other components to be transported with the apparatus **50***b* to reduce road vibrations, such as sensitive or delicate equipment. In the present example, the lithium-ion batteries **75***b* on the racks **70***b* may weigh over about 30,000 kilograms. Accordingly, the trailer **55***b* is configured to mechanically support the mass of the lithium-ion batteries **75***b*. In the present example, the trailer **55***b* is constructed from a plurality of steel beams to form a trailer structure on which the lithium-ion batteries **75***b* and racks **70***b* may be mounted. In the present example, the trailer **55***b* also includes a transportation system **80***b*, with a plurality of wheels **82***b* and a pneumatic suspension system **84***b*. In the present example, the apparatus **50***b* further includes an enclosure **85***b* which may be omitted in other examples where the load carried by the apparatus **50***b* is not substantially affected by weather elements.

In the present example, the isolator springs **65***b* are mounted onto the top surface of the trailer **55***b* as shown in FIG. **4**B. The isolator springs **65***b* are to support the isolation platform **60***b* above the trailer **55***b* to reduce trailer vibrations. The isolator springs **65***b* are not particularly limited and may be any device capable of supporting the weight of the isolation platform **60***b* the intended load of lithium-ion batteries **75***b* on racks **70***b* mounted thereon. Referring to FIG. **4**C, an isolator spring **65***b* is shown in greater detail. In the present example, the isolator spring **65***b* includes a pair of spring elements **66***b*-**1** and **66***b*-**2**. The spring elements **66***b*-**1** and **66***b*-**2** are fastened together with fasteners **67***b*-**1** and **67***b*-**2**. It is to be appreciated by a person of skill with the benefit of this description that the fasteners **67***b*-**1** and **67***b*-**2** are not particularly limited and may include a wide variety of fastening mechanism. In the present example, the fasteners **67***b*-**1** and **67***b*-**2** may be rivets. In other examples, the fasteners **67***b*-**1** and **67***b*-**2** may be bolts. Furthermore, the number of isolator springs **65***b* used to support the isolation platform **60***b* is not particularly limited and may depend on the weight of the lithium-ion batteries **75***b* as well as other components on the isolation platform **60***b*. Although the present example shows eight isolator springs **65***b*, the number of isolator springs **65***b* may be more or less in other examples.

In the present example, the trailer **55***b* includes a transportation system **80***b* with a pneumatic suspension system **84***b* to dampen seismic activity from road vibrations during transportation. The source of the road vibrations is not limited and may be a result of travel over an uneven road surface, weather elements, such as wind, forces from acceleration, deceleration, and turning during transportation. By reducing vibrations, potential damage to the load transported on the isolation platform **60***b*, such as the lithium-ion batteries **75***b* in the present example, is reduced.

The apparatus **50***b* may be used to transport a wide variety of loads that may benefit from a reduction in the amount of vibrations during transit. In the present example, the apparatus **50***b* may include rack **70***b* mounted onto the isolation platform **60***b* to secure a plurality of lithium-ion batteries **75***b*. In the present example, the lithium-ion batteries **75***b* collectively provide the capacity to store energy at a utility-scale, such as with a capacity greater than about 200 kilowatt-hours, for use with a power distribution network.

Referring to FIG. **5**, a representation of another apparatus **50***c* to transport utility-scale lithium-ion batteries in a racked and operational state to different locations is generally shown. Like components of the apparatus **50***c* bear like reference to their counterparts in the apparatus **50**, except followed by the suffix "c". In the present example, the apparatus **50***c* includes a base **55***c*, an isolation platform **60***c*, an isolator **65***c*, a rack **70***c* to secure a plurality of lithium-ion batteries **75***c*, and a transportation system **80***c*. In this example, the transportation system **80***c* is rail wheels to allow the apparatus **50***c* to be transported via rail.

Referring to FIG. **6**, a flowchart of a method of transporting utility-scale lithium-ion batteries in a racked and operational state to different locations is generally shown at **300**. In order to assist in the explanation of method **300**, it will be assumed that method **300** may be performed by the apparatus **50**. Indeed, the method **300** may be one way in which the apparatus **50** may be operated. Furthermore, the following discussion of method **600** may lead to a further understanding of the apparatus **50** and its components. In addition, it is to be emphasized, that method **300** may not be performed in the exact sequence as shown, and various blocks may be performed in parallel rather than in sequence, or in a different sequence altogether.

Beginning at block **310**, forces exerted on the isolation platform **60** are to be dampened using a plurality of isolators **65**. In the present example, the isolators **65** are to be installed between the base **55** and the isolation platform **60**. Accordingly, any vibration of the base **55** will be absorbed by the isolator **65** prior to reaching the isolation platform **60**.

Block **320** involves mounting the racks **70** along with a plurality of lithium-ion batteries **75** onto the isolation platform **60**. The manner by which the lithium-ion batteries **75** are mounted to the isolation platform **60** is not particularly limited. For example, the racks **70** may be welded onto the isolation platform **60**. In other examples, the racks **70** may be bolted onto the isolation platform **60**. In other examples, the racks **70** may also be secured at other positions other than the isolation platform **60** with additional dampeners.

Upon securing the racks **70** and the plurality of lithium-ion batteries **75**, the apparatus is to be transported from one location to another location while the plurality of lithium-ion batteries **75** is racked on the racks **70** and in an operational state at block **330**. It is to be appreciated that by transporting the lithium-ion batteries **75** in a racked an operational state allows the installation and removal of the apparatus **50** from a site faster and more efficient than if the lithium-ion batteries **75** were to be disassembled and separately stored to avoid potential mechanical damage during transportation. Mechanical damage may result in a short circuit that generates additional heat, which may lead to further mechanical damage and damage to neighboring cells. This results in a positive feedback cycle that results in a thermal runaway, which is difficult to stop. It is to be appreciated by a person of skill with the benefit of this description that the risk of mechanical damage to the lithium-ion battery cells is reduced by the apparatus **50**, as vibrational and acceleration forces are effectively and safely transferred to the lithium-ion battery cell support structure.

During the transportation of the apparatus **50***c*, force data may be collected to determine the amount of force exerted on the lithium-ion batteries **75**. For example, force data may provide the greatest force exerted during a transit, such as from an accident or hard braking or turning event. The force data may also be able to provide statistics on the transit, such as the number of events where the force exceeds a threshold, the frequency of force events, and other data. Accordingly, the force data may then be used to provide an indication of the wear and tear the lithium-ion batteries **75** are subjected to for each transit and may be used for driver training and/or discipline. As another example of the use of force data, the force data may be provided to a central monitoring system or driver so that larger forces during transit may be detected in real time and adjustments to driving behavior may be implemented.

Various advantages will now become apparent to a person of skill with the benefit of this description. In particular, the apparatus **50** provides a fully functional lithium-ion battery energy storage system capable of quickly connecting to and disconnecting from a utility grid through a process that does not involve taking the batteries out of the operational state. The apparatus **50** may also include additional safety features for transportation, such as battery and force monitoring as well as lithium outgassing detection.

It should be recognized that features and aspects of the various examples provided above may be combined into further examples that also fall within the scope of the present disclosure.

What is claimed is:

1. An apparatus comprising:
- a base;
- an isolation platform;
- an isolator mounted on the base to support the isolation platform, wherein the isolator is to dampen forces exerted on the isolation platform from the base;
- a rack mounted onto the isolation platform; and
- a plurality of lithium-ion batteries to store energy at a utility-scale to be provided to a power distribution network, wherein the plurality of lithium-ion batteries is secured to the racked in an operational state, and wherein the plurality of lithium-ion batteries remain energized in the operational state during transportation.

2. The apparatus of claim **1**, wherein the base includes a transportation system.

3. The apparatus of claim **2**, wherein the base is a trailer to be towed by a tractor.

4. The apparatus of claim **1**, further comprising an enclosure to protect the plurality of lithium-ion batteries from weather elements.

5. The apparatus of claim **4**, further comprising a dampener to connect a top portion of the rack to a ceiling of the enclosure, wherein the dampener is to secure the rack and to reduce motion of the rack relative to the base.

6. The apparatus of claim **1**, further comprising a shock sensor to collect force data of the forces exerted on the plurality of lithium-ion batteries continuously during transportation.

7. The apparatus of claim **6**, further comprising a monitoring system is to transmit the force data to an operator during transportation.

8. The apparatus of claim **1**, further comprising a weather sensor to collect weather data associated with conditions to which the plurality of lithium-ion batteries are subjected.

9. The apparatus of claim **1**, further comprising a fire suppression system to improve safety of the plurality of lithium-ion batteries during transportation.

10. The apparatus of claim **1**, wherein the isolator is an isolator spring comprising a first spring element and a second spring element, wherein the first spring element and the second spring element are substantially loops, and wherein the first spring element is fastened perpendicular to the second spring element.

11. An apparatus comprising:
- a trailer;
- an pneumatic suspension system disposed on the trailer to reduce road vibrations at a top surface of the trailer during transport;
- a plurality of isolator springs mounted on the top surface of the trailer;
- an isolation platform supported by the plurality of isolator springs, wherein each isolator spring is to reduce trailer vibrations on the isolation platform; and
- a plurality of lithium-ion batteries to store energy at a utility-scale, wherein the plurality of lithium-ion batteries is secured to the isolation platform in an operational state, and wherein the plurality of lithium-ion batteries remain energized in the operational state during transportation.

12. The apparatus of claim **11**, wherein the plurality of lithium-ion batteries is secured to the isolation platform by a rack mounted onto the isolation platform.

13. The apparatus of claim **12**, further comprising an enclosure secured to the trailer, wherein the enclosure is to protect the plurality of lithium-ion batteries from weather elements.

14. The apparatus of claim **13**, further comprising a dampener to connect a top portion of the rack to a ceiling of the enclosure, wherein the dampener is to secure the rack and to reduce motion of the rack relative to the trailer.

15. The apparatus of claim **11**, further comprising a shock sensor to collect force data of forces exerted on the plurality of lithium-ion batteries continuously during transportation.

16. The apparatus of claim **15**, further comprising a monitoring system is to transmit the force data to an operator during transportation.

17. The apparatus of claim **10**, further comprising a weather sensor to collect weather data associated with conditions to which the plurality of lithium-ion batteries are subjected.

18. A method comprising:
- dampening forces exerted on an isolation platform with a plurality of isolators;
- mounting a rack of lithium-ion batteries to store energy at a utility-scale to the isolation platform;
- transporting the lithium-ion batteries in an operational state from a first location to a second location, wherein the lithium-ion batteries is racked during transportation; and

collecting force data of forces exerted on the lithium-ion batteries during transportation.

19. The method of claim **18**, further comprising transmitting the force data to an operator during transportation.

20. The method of claim **18**, further comprising collecting weather data associated with conditions to which the lithium-ion batteries are subjected during transportation.

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