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(54) **A BATTERY-POWERED PARCEL LOCKER WITH A CELL SWITCH AND A METHOD OF SWITCHING CELLS**

(57) A battery-powered parcel locker (10) comprising
- two or more compartments (20), wherein each of the two compartments (20) comprise a gate (22) with a lock unit (24) for controlling access to the compartment;
- a parcel communication module (30) for receiving instructions;
- a parcel locker controller (40) comprising at least one processor and at least one memory that includes program code, wherein the memory and the program code is configured to cause the processor to instruct the two or more lock units (24) to open as a function of received instructions;
- a battery unit (50) for powering at least the parcel locker controller (40), the parcel communication module (30), and the two or more lock units (24); wherein the battery unit (50) comprises a first cell (52I) equipped with one or more batteries (54), a second cell (52II) equipped with one or more batteries (54), the cells (52I, 52II) being in a parallel configuration and a cell switch (60) configured to switch between drawing power from the cells (52I, 52II) as a function of pre-set parameters or received instruction.

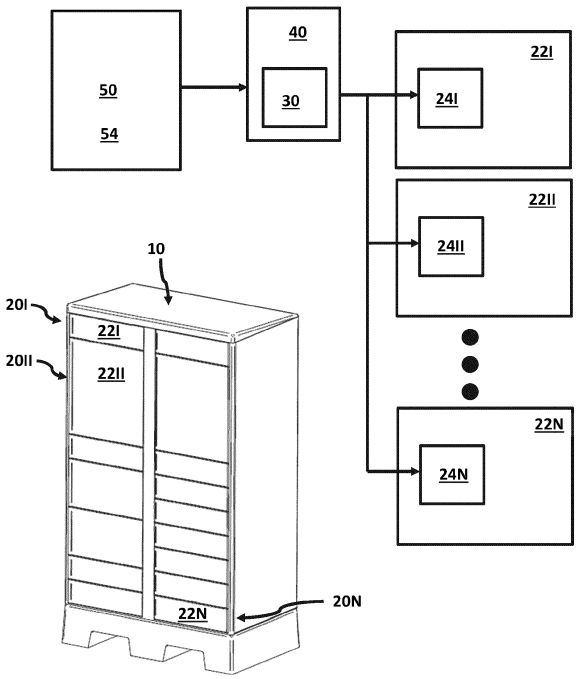


Fig. 1

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## Description

### Field of the Invention

**[0001]** The present invention relates to a battery-powered parcel locker configured for reducing risk of battery power failure and a method for reducing risk of battery power failure.

### Background of the Invention

**[0002]** Battery-powered parcel lockers are the best type of parcel lockers for building a large network of parcel lockers as there are no additional requirements for electric power, which would otherwise increase installation time, planning, and costs.

**[0003]** Since there is no additional power, then the one or more batteries of the parcel lockers become very critical components as the parcel locker cannot function or open any compartments without power.

**[0004]** Some parcel lockers are presently delivered with a ten-year battery warranty. These parcel lockers are also dimensioned for operation for more than ten years without replacing the battery pack. The battery-powered parcel lockers are installed in vastly different environments which can have low temperatures, high temperatures or large temperature ranges and/or high humidity or low humidity and/or low air salt concentrations and/or high air salt concentrations and so on. Thus, the batteries are subjected to various levels of stress. In some environments there is an increased risk that one or more batteries are damaged and/or collapse, however the damage or collapse may also be due to a production error.

**[0005]** Presently, there is a significant risk that such a collapse or damage may cause the battery-powered parcel locker to lose power in its entirety. Thus, there is a need for battery-powered parcel lockers which are designed to be unaffected in at least the short term by a damaged battery or collapsed battery.

### Object of the Invention

**[0006]** It is an object of the invention to provide a method and a battery-powered parcel locker, which can operate unaffected even with a damaged battery or collapsed battery.

### Description of the Invention

**[0007]** An object of the invention is achieved by a battery-powered parcel locker comprising

- two or more compartments, wherein each of the two compartments comprise a gate with a lock unit for controlling access to the compartment;
- a parcel communication module for receiving instructions;
- a parcel locker controller comprising at least one processor and at least one memory that includes program code, wherein the memory and the program code are configured to cause the processor to instruct the two or more lock units to open as a function of received instructions;
- a battery unit for powering at least the parcel locker controller, the parcel communication module and the two or more lock units; wherein the battery unit comprises a first cell equipped with one or more batteries, a second cell equipped with one or more batteries, the cells being in a parallel configuration and a cell switch configured to switch between drawing power from the cells as a function of pre-set parameters or received instruction.

**[0008]** The parcel communication module for enabling a user to communicate with the battery-powered parcel locker and sent instruction to the parcel locker which instructions cause the parcel locker controller to instruct one or more of the two or more lock units to open.

**[0009]** The two cells of the battery unit and the cell switch enable that one of the cells i.e., one of the batteries, can be damaged or collapsed. However, this will not affect the other cell, and this other cell may then provide power to the parcel locker such that the parcel locker can function unaffected for an extended period. Each cell is configured to be able to power the parcel locker without any additional power or current from the other cells.

**[0010]** The cells are typically dimensioned such that the cells can power the parcel locker for at least 10 years, however, even if the cells were dimensioned to power the parcel locker for 5 years or 3 years or 2 years or 1 year, then if one cell is damaged such that it no longer can be used for powering the parcel locker then the remaining cell or cells will be able to power the parcel locker for months if not years. As an example, if the battery unit comprises two cells dimensioned for powering the parcel locker for at least 10 years, then each cell will be dimensioned to power the parcel locker for at least 5 years, thus in case of failure of one cell then the other cell may be able to power the cell for months or years without maintenance. Thus, the parcel locker will be unaffected in the short term since there is not a single point of failure of the battery unit.

**[0011]** The cell switch may be configured to switch cells if it is registered by the parcel locker controller that a lock unit has not been opened or if the parcel communication module receives instruction to switch cells. This may further cause the parcel locker controller to stop switching to the cell which is unable to open a lock unit.

**[0012]** Another effect of having a cell switch is that it is ensured that power is drawn from both cells. The parcel locker could function without a cell switch i.e. cells are connected in parallel, but that would increase a risk of one or more cells developing a too great passivation layer, which would obstruct the flow of current from said cells such that power is only delivered from a sub-set of

all the cells with a lower passivation layer. This is specially an issue when using primary batteries such as lithium thionyl chloride (Li-SoCl2 batteries) or iron disulfate (LiFeS2), or lithium manganese dioxide (LiMnO2), or lithium metal-oxide. Thus, the switching will ensure that the power used is roughly the same from each cell.

**[0013]** The pre-set parameters may be a pre-set time period such as every 24 hours or every 12 hours or every 6 hours or 3 hours or 1.5 hours or every 2 days or other periods.

**[0014]** The pre-set parameters may be an estimated energy consumption such that the cells are switched when a certain amount of estimated energy has been used from the cell.

**[0015]** The received instructions may be received from a courier or recipient being unable to open one or more compartments and thus sending via a smart device an instruction to change battery cells and optionally, to exclude the present battery cell from the switching. This may be performed while informing an external server, such as a distribution server, that the battery-powered parcel locker needs maintenance.

**[0016]** The received instructions may be from the battery-powered parcel locker detecting a defect battery cell.

**[0017]** The battery-powered parcel locker may comprise five or more compartments or ten or more compartments or sixteen or more compartments or eighteen or more compartments or twenty or more compartments, wherein each compartment comprises a gate with a lock unit for controlling access to the compartment.

**[0018]** In an aspect, the parcel locker controller may be configured to send instruction to the cell switch as a function of pre-set parameters or received instruction. Thereby, the parcel locker controller ensures that the cells are switched by the cell switch.

**[0019]** In an aspect, the cell switch may comprise a switch energy source powering a switch controller configured to cause the cell switch to switch between drawing power to the cells as a function of pre-set period. Thereby, the cell switch can be powered even if one of the cells are damaged and not delivering any electric power thereby enabling switching even though the cell is suddenly damaged.

**[0020]** The switch energy source may be a battery such as a coin battery or a capacitor charged by the cell currently powering the rest of the parcel locker or one of the cells. The switch controller may then be configured to switch in case of a loss of capacitance or another measurement of loss of power.

**[0021]** In an aspect, the parcel communication module may comprise one or more of the following

- a Bluetooth communication module, preferably a Bluetooth low-energy communication module;
- a numpad;
- NFC module;
- a microphone;
- a ZigBee module;
- a GSM module; or
- a WiFi module.

**[0022]** Bluetooth is part of almost all smart phones or other smart devices and hence the Bluetooth communication module will enable almost everyone to control the battery powered parcel locker. Here, it is preferable if the Bluetooth module is Bluetooth low-energy as it will use less energy and ensure longer lifetime.

**[0023]** The numpad enables a simple and low-powered method for users to gain access to the battery-powered parcel locker, where access is granted to a compartment as a function of input.

**[0024]** An NFC module and/or a ZigBee module may be used for receiving instructions for providing access to one or more of the two or more compartments.

**[0025]** A microphone may be used for receiving instruction via sound waves emitted from a smart device with a speaker.

**[0026]** The latest versions of GSM modules can have a low energy consumption, which will prolong the operation time before the batteries must be replaced.

**[0027]** Furthermore, the parcel communication module may include a WiFi module, however presently a WiFi module should be used as little as possible if the aim is to keep the power consumption as low as possible to extend the period between change of batteries.

**[0028]** In an aspect, wherein the batteries may be primary batteries such as a wet type battery, preferably Li-SoCl2 batteries, or manganese batteries, or manganese batteries, or iron disulfate (LiFeS2) batteries, lithium manganese dioxide (LiMnO2) batteries, or lithium metal-oxide batteries, or high impedance batteries.

**[0029]** The primary battery is preferably a battery with a high impedance resulting in a low self-discharge rate. This may be Lithium thionyl chloride (Li-SoCl2) batteries, however other batteries with a similar impedance and low discharge rate can be used.

**[0030]** Lithium thionyl chloride (Li-SoCl2) batteries are well known for having a high energy density and a very low self-discharge enabling the lithium thionyl chloride (Li-SoCl2) batteries to power a parcel locker for at least ten years. Furthermore, the Li-SoCl2 batteries will provide a very stable voltage until the end of the lifetime of the battery. Therefore, the batteries are preferably Li-SoCl2 batteries.

**[0031]** The batteries may be manganese battery, however, the manganese battery has a higher self-discharge than the Li-SoCl2 batteries and lower energy density thus a battery powered parcel locker may have a 3 year lifetime without replacement of the battery pack when the batteries are manganese battery.

**[0032]** In an aspect, the battery-powered parcel locker further may comprise one or more voltage comparators configured for comparing cell voltage with a reference voltage.

**[0033]** The voltage comparator may be positioned after the cell switch which enables only a single voltage com-

parator to be used. In other embodiments, the one or more voltage comparators may be positioned between each cell and the cell switch. The comparator has a reference voltage source which may be a Zener diode or similar.

**[0034]** The purpose of comparator is not to check whether the cell can provide sufficient power for opening a lock unit as the cell may be able to provide sufficient power even if the cell has a damaged battery. In some embodiments, such as the embodiment where a super capacitor is used for powering the lock units, the load on the cell is for the slow recharging of the super capacitor and thus it does not as such make sense to perform the measurement during the unlocking of the lock unit. However, in some embodiments, the parcel locker controller is configured to perform the measurement during unlocking of a lock unit.

**[0035]** Furthermore, a high impedance battery will have a drop in voltage after electric power has been drawn from the high impedance battery, however the battery will, if functioning correctly and having more electric energy stored in the battery, return to the nominal voltage. The battery-powered parcel locker will always have an active cell, from which power is drawn, and a passive cell. Both cells will continuously restore the voltage towards the nominal voltage. Thus, the comparison may be made before or after the cell switch because if the passive cell has not been able to store the voltage to or at least close to the nominal voltage, then it is likely that the cell has at least one damaged or collapsed or otherwise not functioning battery. Typically, the cell switch will perform a switch once every 24 hours and this should be sufficient for a high impedance battery, such as a Li-SoCl2 battery, to return to the nominal voltage, and if the battery or cell voltage is still significantly below nominal voltage, then this will likely point towards one or more of the batteries being non-functioning.

**[0036]** For the embodiments wherein the batteries are Li-SoCl2 batteries, the purpose of the voltage comparator is to detect whether the cell has a damaged or collapsed battery as it is not possible to use the voltage comparative to determine or to estimate remaining energy stored on the Li-SoCl2 batteries. However, if the cell fails the comparative test, then the parcel locker controller may be configured such that cell switch will not switch to this cell. If the parcel locker only has a first and second cell, then the switching will stop and preferably the parcel locker controller will send an alarm to an external server such that the external server can order maintenance for replacement of at least the damaged parcel locker. The maintenance will very rarely be urgent as in the most cases the other cell or cells may be able to power the battery-powered parcel locker for up to several years. However, another cell failure may cause the parcel locker to stop being powered.

**[0037]** The alarm may be sent to the external server via a third-party device such as a smart device or smart phone. The alarm may be sent when a recipient collects a parcel or when a courier delivers parcels to the parcel locker. In the embodiments, where the parcel locker does not have means for electronic communication then the alarm may be in the form of a diode or similar, to communicate to the courier that at least one cell must be replaced, and the courier will then send an alarm to the external server such that maintenance is requested.

**[0038]** There are limitations to the precision and there will be damaged cells which will pass a test comparing the cell voltage to a reference voltage. However, if a recipient of a parcel or a courier is not able to open a compartment then the fault can be reported, and one initial option is to send instructions to the parcel locker through a third-party device (such as a smart phone) to switch cells. If the parcel locker is then able to open the compartment, then it is a sign that the previous cell is non-functioning.

**[0039]** In an aspect, the parcel locker may comprise a super capacitor configured for powering at least the two or more lock units and optionally the parcel locker controller and the parcel communication module; wherein the battery unit is being configured for charging the super capacitor.

**[0040]** The super capacitor can provide a peak current to the two or more lock units which can be observed during unlocking of one of the two or more lock units without stressing or damaging the super capacitor. This is particularly relevant to embodiments powered by Li-SoCl2 batteries or similar high impedance batteries which are damaged or deteriorated by the peak load, however the Li-SoCl2 batteries can still be used for charging the super capacitor. An off-the-shelf super capacitor can when fully charged have enough power to open a lock unit 10-20 times without discharging depending on the super capacitor and lock unit. This may be more times than lock units in the parcel locker such that the SoCl2 batteries may slowly charge the super capacitor in between unlocking, and in case all parcels are collected at once, then the SoCl2 batteries will in general have hours for charging the super capacitor until the parcel locker is refilled by a courier.

**[0041]** The super capacitor will however have a higher discharge rate compared to SoCl2 batteries or similar batteries, and thus the total operation time without replacement will decrease for the battery-powered parcel locker.

**[0042]** In an aspect, the parcel locker may comprise a thermistor between the battery unit and the two or more lock units. The thermistor will reduce the peak current observed during the unlocking of one of the two or more lock units since, as previously mentioned, peak currents are particularly harmful for SoCl2 batteries or similar types of batteries. The thermistor will thus protect the battery unit and prevent collapse or similar unwanted effects and thereby decrease maintenance cost and downtime.

**[0043]** The thermistor may likewise be between the battery unit and parcel communication module and/or

parcel locker controller, however the parcel communication module and parcel locker controller will in general not draw any peak currents and thus it is not essential that the thermistor is between the battery unit and parcel communication module and/or parcel locker controller.

**[0044]** In an aspect, the battery unit may comprise a lock unit battery cell configured to power the two or more lock units, wherein the parcel locker controller is configured to control powering of the two or more lock units and the lock unit battery cell comprise one or more batteries. Thereby, the lock unit battery cell can be specifically designed to just power the unlocking of the two or more lock units i.e. the lock unit battery cell can be made of batteries which can withstand a high peak current without deteriorate.

**[0045]** The one or more batteries forming part of the lock unit battery cell may be one or more Li-SoCl2 batteries or one or more manganese batteries, or one or more iron disulfate (LiFeS2) batteries, one or more lithium manganese dioxide (LiMnO2) batteries, or one or more lithium metal-oxide batteries, or one or more high impedance batteries.

**[0046]** In the embodiments using Li-SoCl2 batteries or batteries with a similar high impedance as Li-SoCl2 batteries, then the parcel locker may comprise a thermistor between the lock unit battery cell and the two or more lock units. In other embodiments, the parcel locker comprises a super capacitor configured to be charged by the lock unit battery cell, wherein the super capacitor is configured for powering at least the two or more lock units.

**[0047]** The battery unit may have at least two lock unit battery cells and a second cell switch, which function similar to the other cell switch and ensure that there is no single point of failure.

**[0048]** In an aspect, the one or more batteries may comprise one or more manganese batteries. Manganese batteries are capable of providing a high current and have a large energy density enabling a long operation lifetime. The manganese batteries may be lithium manganese dioxide (LiMnO2) batteries.

**[0049]** An object of the invention is achieved by a method for switching battery cells of a battery-powered parcel locker including two or more lock units adapted for providing access to a compartment as a function of received instructions, wherein the method comprises steps of

- providing a battery-powered parcel locker comprising two or more cells comprising one or more batteries, wherein each cell being dimensioned and configured to power the parcel locker;
- switching between the two or more cells as a function of pre-set parameters or received instruction.

**[0050]** The method will prevent formation of a too large passivation layer causing only one of the battery cells to provide power to the parcel locker. Thereby, it is roughly ensured that each battery cell has the same energy left at any given time. Thus, in case of failure of one of the battery cells then the other battery cells can still be used for powering the parcel locker until repairs are performed by maintenance or the non-functioning battery cell(s) are replaced. Each of the battery cells are configured for powering the battery parcel locker alone without any additional battery cells such that all other battery cells can fail without affecting the operation of the battery-powered parcel locker for an extended period enabling maintenance.

**[0051]** The received instructions may be received from a courier or recipient being unable to open one or more compartments and thus sending via a smart device an instruction to change battery cells and optionally, to exclude the present battery cell from the switching. This may be performed while informing an external server such as a distribution server that the battery-powered parcel locker needs maintenance.

**[0052]** The received instructions may be from the battery-powered parcel locker detecting a defect battery cell.

**[0053]** In an aspect of the method, the pre-set parameters are chosen among numbers of actions performed at the parcel locker or a pre-set period or energy consumption or a combination.

**[0054]** The pre-set parameters may be a pre-set period such as once per 24 hours or every 12 hours or every 6 hours or 3 hours or 1.5 hours or every 2 days or other periods.

**[0055]** The pre-set parameters may be an estimated energy consumption such that the cells are switched when a certain amount of estimated energy has been used from the cell.

**[0056]** In an aspect of the method, at least one of the battery cells being primary batteries such as a wet type battery and preferably Li-SoCl2 batteries, or manganese batteries, or iron disulfate (LiFeS2), or lithium manganese dioxide (LiMnO2), or lithium metal-oxide, or high impedance batteries.

**[0057]** The Li-SoCl2 batteries have a low self-discharge rate, which makes them an excellent solution for a battery-powered parcel locker, which should be operational without any need for maintenance for several years such as at least 3 years or 5 years or preferably 10 years or more years. The cost for battery replacement of a decentralized network of more than 10.000 parcel lockers is expensive and thus it is preferred to have a long operation time such as 10 years. The maintenance cost for a network of parcel lockers with 10 years of battery operation time will be less than a third of a network with 3 years of battery operation time.

**[0058]** The parcel locker may use high impedance batteries similar to Li-SoCl2 batteries, which have a large impedance and thus low self-discharge rate as this makes the high impedance batteries suitable for 5 years or 10 years or more years of service without maintenance.

**[0059]** In an aspect of the method, the battery-powered parcel locker comprises two or more lock unit battery cells configured to powering lock units during unlocking,

wherein each lock unit battery cell comprises one or more manganese batteries and the step of switching includes switching between the two or more lock unit battery cells as a function of the pre-set parameters or instructions.

**[0060]** Thereby, a battery type is provided which can withstand peak currents, which is present during unlocking of the lock units unless components are added to prevent the high peak currents. By using manganese batteries there is no need to add additional components. By switching between the manganese batteries then the method has no single point of failure.

**[0061]** In an aspect of the method, the method further comprises steps of

- comparing a voltage of one of the cells with a reference voltage; and
    - sending an alarm as a function of the step of comparing; and/or
    - removing the battery cell from the switching cycle.

**[0062]** Li-SoCl2 batteries have a very low discharge rate, and the voltage is almost constant until all electric energy is consumed. Thus, the step of comparing with a reference voltage is not to estimate the remaining energy of the battery cell or whether the battery cell has sufficient energy to open a lock unit as this would not be possible for Li-SoCl2 batteries using this method. Furthermore, if the battery unit is configured and dimensioned for powering the parcel locker for 10 years, then it should not be necessary to measure the remaining energy.

**[0063]** The reference voltage is chosen depending on the local environment at the battery powered parcel locker and the type of battery. The voltage of the batteries will in many cases depend heavily on temperature of the batteries, thus the reference voltage should be selected on a case-to-case basis.

**[0064]** In an embodiment, the method further comprises the following step during a step of opening of one of the lock units;

- comparing a voltage of one of the cells with a reference voltage; and
- sending an alarm as a function of the step of comparing; and/or
- removing the battery cell from the switching cycle.

**[0065]** Instead, the purpose of the step of comparing is to identify whether one or more of the one or more batteries forming the cell have been damaged or are broken, such as collapsed. In these cases, the voltage of the one or broken batteries will drop significantly and even for a Li-SoCl2 battery the drop in voltage will be significant and easily observable.

**[0066]** The method may then send an alarm to an external server which may be through a third-party device in communication with the parcel locker. The external server may after receiving an alarm, request maintenance of the battery-powered parcel locker. Since the parcel locker has at least two cells, then the maintenance does not need to be urgent as there will typically be energy for powering the parcel locker for months if not years on the other cell or cells.

**[0067]** The method may remove the battery cell from the switching cycle until the battery cell has been repaired or replaced. Thereby, there will be no change of operation for the battery-powered parcel locker.

**[0068]** The reference voltage may be a Zener diode.

**[0069]** An object of the invention is achieved by a battery-powered parcel locker. The battery-powered parcel locker comprises

- two or more compartments, wherein each of the two compartments comprise a gate with a lock unit for controlling access to the compartment;
- a parcel communication module for receiving instructions;
- a parcel locker controller comprising at least one processor and at least one memory that includes program code, wherein the memory and the program code is configured to cause the processor to instruct the two or more lock units to open as a function of received instructions;
- a battery unit for powering at least the parcel locker controller, the parcel communication module, and the two or more lock units; wherein the battery unit comprises a first cell equipped with one or more batteries, a second cell equipped with one or more batteries, the cells being in a parallel configuration, wherein the batteries are primary batteries and the batteries define a non-destructive current direction, wherein each cell comprises a diode preventing current flow reverse to the non-destructive current direction.

**[0070]** A primary battery will, in the event of a current flow reverse to the non-destructive current direction, be severely damaged or collapse. The reverse current flow can happen when two cells are in the parallel configuration and the two cells are not balanced. It has happened that a battery in one cell collapses and this causes an imbalance resulting in a reverse current flow through the other cell. If the parcel locker has more cells, then this will cascade through all the cells. This is a rare occurrence, however when this happens the parcel locker fails entirely, and it may not even be possible to power the parcel locker controller. Thus, the diodes greatly reduce the risk of failure by the diodes alone or in combination with the cell switch which enables the remaining cell or cells to power the parcel locker until maintenance, undisturbed by the non-functioning cell.

**Description of the Drawing**

**[0071]** Embodiments of the invention will be described

in the figures, whereon:

Fig. 1 illustrates a battery-powered parcel locker with N compartments;
Fig. 2 illustrates two embodiments of a battery unit for a battery-powered parcel locker;
Fig. 3 illustrates functioning of voltage comparators;
Fig. 4 illustrates a battery-powered parcel locker with N compartments with a thermistor;
Fig. 5 illustrates a battery-powered parcel locker with N compartments with a super capacitor;
Fig. 6 illustrates a battery-powered parcel locker with a battery unit comprising lock unit battery cells;
Fig. 7 illustrates a method for switching battery cells of a battery-powered parcel locker; and
Fig. 8 illustrates a battery-powered parcel locker with N compartments with diodes for protecting primary batteries.

## Detailed Description of the Invention

**[0072]**

| Item | No |
|---|---|
| Battery-powered parcel locker | 10 |
| Compartment | 20 |
| Gate | 22 |
| Lock unit | 24 |
| Parcel communication module | 30 |
| Parcel locker controller | 40 |
| Battery unit | 50 |
| Cell | 52, 52I, 52II |
| Lock unit battery cell | 53, 53I, 53II |
| Battery | 54 |
| Super capacitor | 56 |
| Thermistor | 58 |
| Diode | 59I, 59II |
| Cell switch | 60 |
| Switch energy source | 62 |
| Switch controller | 64 |
| Voltage comparator | 70 |
| External server | 90 |
| Method | 1000 |
| Providing | 1100 |
| Switching | 1200 |
| Opening | 1300 |
| Comparing | 1400 |

(continued)

| Item | No |
|---|---|
| Sending | 1500 |
| Removing | 1600 |

**[0073]** Fig. 1 illustrates a battery-powered parcel locker 10 with N compartments 20I,..., 20N. Each of the N compartments 20I,..., 20N comprise a gate 22I,..., 22N with a lock unit 24I,..., 24N. The lock unit 24 may be a common latch.

**[0074]** The battery-powered parcel locker 10 further comprises a parcel communication module 30 for receiving instructions. The parcel communication module 30 may comprise one or more of the following

- a Bluetooth communication module, preferably a Bluetooth low-energy communication module;
- a numpad for providing a code;
- NFC module for receiving instructions;
- a microphone for receiving instructions;
- a ZigBee module;
- a GSM module; or
- a WiFi module.

**[0075]** The battery-powered parcel locker 10 further comprises a parcel locker controller 40 comprising at least one processor and at least one memory that includes program code, wherein the memory and the program code are configured to cause the processor to instruct the two or more lock units 24 to open as a function of received instructions. The received instruction is received via the communication module 30. The communication module 30 may be part of the parcel locker controller 40.

**[0076]** The shown embodiment includes a battery unit 50 comprising one or more batteries 54 for powering the parcel locker 10 for three years or five years or seven years or ten years. Two embodiments of the battery unit are disclosed in figure 2.

**[0077]** Fig. 2 illustrates two embodiments of a battery unit 50 for a battery-powered parcel locker 10.

**[0078]** Fig. 2A discloses a battery unit 50 for powering at least the parcel locker controller 40, the parcel communication module 30, and the two or more lock units 24. The battery unit 50 comprises a first cell 52I equipped with two batteries 54, however, it could be a single battery 54 or more batteries 54. The battery unit 50 comprises a second cell 52II equipped with two batteries 54, however, it could be a single battery 54 or more batteries 54. The cells 52I, 52II are in a parallel configuration. Two cells 52I, 52II are shown but the battery 50 unit could have three or more cells 52I, 52II.

**[0079]** The cell switch 60 configured to switch between drawing power from the cells 52I, 52II as a function of pre-set parameters or received instruction. Thereby, it is

prevented that one cell 52I, 52II builds a greater passivation layer than the other cell 52II, 52I such that power is only drawn from one of the cells 52I, 52II. Each of the cells 52I, 52II are dimensioned to power the parcel locker 10 and each cell 52I, 52II may provide 5 years of power to the parcel locker 10. In case of failure of one of the cells 52I, 52II then the other cell 52I, 52II or cells 52I, 52II would be able to power the parcel locker 10 for months or years before receiving maintenance. Thereby, the battery unit 50, and thus the parcel locker 10, does not have a single point of failure.

**[0080]** The parcel locker controller 40 may be configured to send instruction to the cell switch 60 as a function of the pre-set parameters or received instruction.

**[0081]** The shown embodiment has a diode between each of the cells 52I, 52II and the cell switch 60. The diodes are optional and are not required for the cell switch 60 to function to prevent passivation layer. However, the diodes provide extra protection and prevent current in a destructive direction which is important as the batteries 54 are primary batteries in many embodiments such as Li-SoCl2 batteries which have a low self-discharge rate. The batteries 54 may be high impedance batteries having a similar self-discharge as Li-SoCl2 batteries. The batteries 54 may be the batteries listed in the general description.

**[0082]** The battery unit may optionally comprise two voltage comparators 70, each voltage comparator 70 being connected between the cells 52I, 52II and the cell switch 60. However, the two-voltage comparator 70 could be replaced by a single voltage comparator 70 if placed after the cell switch 60 as illustrated in figure 2B.

**[0083]** Fig. 2B discloses a battery unit 50 for powering at least the parcel locker controller 40, the parcel communication module 30, and the two or more lock units 24. The battery unit 50 comprises a first cell 52I equipped with two batteries 54, however, it could be a single battery 54 or more batteries 54. The battery unit 50 comprises a second cell 52II equipped with two batteries 54, however it could be a single battery 54 or more batteries 54. The cells 52I, 52II are in a parallel configuration. Two cells 52I, 52II are shown but the battery 50 unit could have three or more cells 52I, 52II.

**[0084]** The cell switch 60 configured to switch between drawing power from the cells 52I, 52II as a function of pre-set parameters or received instruction. Thereby, it is prevented that one cell 52I, 52II builds a greater passivation layer than the other cell 52II, 52I such that power is only drawn from one of the cells 52I, 52II. Each of the cells 52I, 52II are dimensioned to power the parcel locker 10 and each cell 52I, 52II may provide 5 years of power to the parcel locker 10. In case of failure of one of the cells 52I, 52II then the other cell 52I, 52II or cells 52I, 52II would be able to power the parcel locker 10 for months or years before receiving maintenance. Thereby, the battery unit, 50 and thus the parcel locker 10, does not have a single point of failure.

**[0085]** The cell switch 60 comprises a switch energy source 62 powering a switch controller 64 configured to cause the cell switch 60 to switch between drawing power to the cells 52I, 52II as a function of the pre-set parameters or received instruction. The switch energy source 62 may be another battery such as a rechargeable battery being recharge by a solar panel. The switch energy source 62 may be one or both the cells 52I, 52II.

**[0086]** The switch energy source 62 may be a lock unit battery cell as described in figure 6. The switch energy source 62 may be a supercapacitor.

**[0087]** The shown embodiment has a diode between each of the cells 52I, 52II and the cell switch 60. The diodes are optional and are not required for the cell switch 60 to function to prevent passivation layer. However, the diodes provide extra protection and prevent current in a destructive direction which is important as the batteries 54 are primary batteries in many embodiments such as Li-SoCl2 batteries which have a low self-discharge rate.

**[0088]** The battery unit may optionally comprise a single voltage comparator 70 placed after the cell switch 60 to determine whether the battery cell 52I, 52II, from which power is drawn, is still functioning. However, the embodiment could be similar to figure 2A where the battery unit comprises two voltage comparators 70 measuring each cell 52I, 52II specifically.

**[0089]** Fig. 3 illustrates functioning of voltage comparators 70. The shown embodiment has a voltage comparator 70 measuring one cell 52I, 52II similar to figure 2A. However, the embodiment shown in figure 2B functions in the same way.

**[0090]** The voltage comparator 70 compares the cell voltage with a reference voltage ($V_{ref}$). In most embodiments, the battery is a battery with a low self-discharge, such as a Li-SoCl2 battery. This type of battery does not have a gradual drop in voltage, instead the drop in voltage is very sudden at the end of life or if the battery is damaged or collapses. In an embodiment, the battery cells 52I, 52II comprise two batteries 54 each with a voltage of 3.6 V and in this case the reference voltage can be a voltage above 3.7 V, however, the reference voltage will typically be 4.5-6.5 V depending on many different factors such as temperature at the future placement of the parcel locker. If a battery is damaged or collapses, then the voltage may become negative but in many cases the battery will still have a small voltage, thus the reference voltage should not be too close to the nominal voltage of one battery as this may result in a false measurement.

**[0091]** The voltage comparators 70 communicate the result to the parcel locker controller 40, which causes the parcel communication module 30 to send a communication to an external server 90. In most cases, the parcel communication module 30 communicates with the external server 90 through a third-party device not shown in the figure. The external server 90 may then estimate when maintenance should or must be performed. The external server 90 can then order maintenance for the battery-powered parcel locker 10 with a defect cell 52I,52II, while the battery-powered parcel locker 10 con-

tinues to operate unaffected by the defect cell (52I,52II). The communication is represented in the figure by 0/1.

**[0092]** Fig. 4 illustrates a battery-powered parcel locker 10 with N compartments with a thermistor 58. The battery-powered parcel locker 10 shown in figure 4 has the same features as the parcel locker shown in figure 1. The battery unit 50 will in most embodiments be similar to the embodiments shown and described in figures 2 and 3.

**[0093]** In many embodiments, the batteries 54 used will be primary batteries such as Li-SoCl2 batteries or similar high impedance batteries. The lock units 24 will during opening draw a high peak current from the one or more Li-SoCl2 batteries which peak current will deteriorates the one or more Li-SoCl2 batteries and this increases risk of a collapse or damage of the one or more Li-SoCl2 batteries i.e. the peak current causes the average lifetime of the batteries 54 to be reduced. The purpose of the thermistor 58 is to reduce the peak and thereby increase the average lifetime of the batteries by less deterioration.

**[0094]** Fig. 5 illustrates a battery-powered parcel locker 10 with N compartments with a super capacitor 56. The battery-powered parcel locker 10 shown in figure 4 has the same features as the parcel locker shown in figure 1. The battery unit 50 will in most embodiments be similar to the embodiments shown and described in figures 2 and 3.

**[0095]** The parcel locker 10 further comprises a super capacitor 56 configured for powering at least the two or more lock units 24 and the parcel locker controller 40 and the parcel communication module 30. The battery unit 50 is configured for charging the super capacitor 56. The super capacitor 56 is almost able to provide any current and for the specific case of this parcel locker 10 all the necessary power and peak current for all purposes including the high peak current doing opening of the one or more lock units.

**[0096]** Fig. 6 illustrates a battery-powered parcel locker 10 with a battery unit 50 comprising lock unit battery cells 53I,53II. The battery-powered parcel locker 10 shown in figure 4 has the same features as the parcel locker shown in figure 1. The battery unit 50 will in most embodiments be similar to the embodiments shown and described in figures 2 and 3 with the addition of the lock unit battery cells 53I,53II. The cells 52I, 52II will in most embodiments have batteries 54 being primary batteries such as one or more Li-SoCl2 batteries. The lock units 24 will during opening draw a high peak current from the one or more Li-SoCl2 batteries which peak current will deteriorate the one or more Li-SoCl2 batteries and this increases risk of a collapse or damage of the one or more Li-SoCl2 batteries i.e., the peak current causes the average lifetime of the batteries 54 to be reduced. This is avoided by the cells 52I,52II not providing power to the lock units 24I, ..., 24N instead the parcel locker controller 40 controls, when the lock unit battery cells 53I,53II provide power to one or more of the lock units 24I, ..., 24N. Although not shown, the lock unit battery cells 53I,53II may also be equipped with a comparator or two comparators 70 similar to the embodiment shown in figure 3.

**[0097]** The lock unit battery cells 53I,53II may each comprise one or more batteries 54 suitable for drawing a high peak current such as manganese batteries (lithium ion manganese oxide battery).

**[0098]** Fig. 7 illustrates a method 1000 for switching battery cells 52I, 52II of a battery-powered parcel locker 10 including two or more lock units 24 adapted for providing access to a compartment 20 as a function of received instructions. The method 1000 comprises steps of

- providing 1100 a battery-powered parcel locker 10 comprising two or more cells 52I, 52II comprising one or more batteries 54, wherein each cell is dimensioned and configured to power the parcel locker 10;
- switching 1200 between the two or more cells 52I, 52II as a function of pre-set parameters or received instruction.

**[0099]** Thereby, none of the cells 52I, 52II forms passivation layer great enough such that only power is drawn from one of the cells 52I, 52II, which is a risk when two or more cells 52I, 52II are installed in a parallel configuration without any switching.

**[0100]** The pre-set parameters may be chosen among numbers of actions performed at the parcel locker 10 or a pre-set period or energy consumption or a combination.

**[0101]** At least one of the battery cells may be primary batteries such as a wet type battery and preferably Li-SoCl2 batteries or manganese battery.

**[0102]** The battery-powered parcel locker 10 may comprise two or more lock unit battery cells 53I, 53II configured to powering lock units 24 during unlocking, wherein each lock unit battery cells 53I, 53II comprise one or more manganese batteries and the step of switching 1200 includes switching between the two or more lock unit battery cells 53I, 53II as a function of the pre-set parameters or instructions.

**[0103]** The reference voltage is chosen depending on the local environment at the battery powered parcel locker 10 and the type of battery 54. The voltage of the batteries 54 will in many cases depend heavily on temperature of the batteries 54, thus the reference voltage should be selected on a case-to-case basis.

**[0104]** The method may further comprise the following steps;

- comparing 1400 a voltage of one of the cells 52I, 52II, 53I, 53II with a reference voltage; and
- sending 1500 an alarm as a function of the step of comparing 1400; and/or
- removing 1600 the battery cell 1400 from the switching cycle.

**[0105]** There are limitations to the precision and there will be damaged cells which will pass a test comparing

the cell voltage to a reference voltage. However, if a recipient of a parcel or a courier is not able to open a compartment then the fault can be reported, and one initial option is to send instructions to the parcel locker through a third-party device (such as a smart phone) to switch cells. If the parcel locker is, then able to open the compartment, then it is a sign that the previous cell is non-functioning.

**[0106]** The method may further comprise the following step during a step of opening 1300 one of the lock units 24;

- comparing 1400 a voltage of one of the cells 52I, 52II, 53I, 53II with a reference voltage; and
- sending 1500 an alarm as a function of the step of comparing 1400; and/or
- removing 1600 the battery cell 1400 from the switching cycle.

**[0107]** Fig. 8 illustrates a battery-powered parcel locker 10 with N compartments 20 with diodes 59I, 59II for protecting primary batteries 54. The battery-powered parcel locker 10 comprises

- two or more compartments 20, wherein each of the two compartments (20) comprise a gate 22 with a lock unit 24 for controlling access to the compartment;
- a parcel communication module 30 for receiving instructions;
- a parcel locker controller 40 comprising at least one processor and at least one memory that includes program code, wherein the memory and the program code is configured to cause the processor to instruct the two or more lock units 24 to open as a function of received instructions;
- a battery unit 50 for powering at least the parcel locker controller 40, the parcel communication module 30, and the two or more lock units 24.

**[0108]** The battery unit 50 comprises a first cell 52I equipped with one or more batteries 54, a second cell 52II equipped with one or more batteries 54. The cells 52I, 52II are in a parallel configuration. The batteries 54 are primary batteries and the batteries 54 define a non-destructive current direction, wherein each cell 52I, 52II comprises a diode 59I, 59II preventing current flow from reversing to the non-destructive current direction.

**[0109]** A primary battery will in the event a current flow reverses to the non-destructive current direction be severely damaged or collapse. The reverse current flow can happen when two cells are in the parallel configuration and the two cells are not balanced. It has happened that a battery in one cell 52I, 52II collapses and this causes an imbalance resulting in a reverse current flow through the other cell 52II, 52I. If the parcel locker 10 has more cells 52I, 52II then this will cascade through all the cells. This is a rare occurrence, however when this happens the parcel locker 10 fails entirely and it may not even be possible to power the parcel locker controller 40. Thus, the diodes 59I, 59II greatly reduces the risk of failure by the diodes alone or in combination with the cell switch 60 (not shown) which enables the remaining cell 52I, 52II or cells 52I, 52II to power the parcel locker 10 until maintenance, undisturbed by the non-functioning cell 52I, 52II.

## Claims

**1.** A battery-powered parcel locker (10) comprising

- two or more compartments (20), wherein each of the two compartments (20) comprise a gate (22) with a lock unit (24) for controlling access to the compartment;
- a parcel communication module (30) for receiving instructions;
- a parcel locker controller (40) comprising at least one processor and at least one memory that includes program code, wherein the memory and the program code is configured to cause the processor to instruct the two or more lock units (24) to open as a function of received instructions;
- a battery unit (50) for powering at least the parcel locker controller (40), the parcel communication module (30), and the two or more lock units (24); wherein the battery unit (50) comprises a first cell (52I) equipped with one or more batteries (54), a second cell (52II) equipped with one or more batteries (54), the cells (52I, 52II) being in a parallel configuration and a cell switch (60) configured to switch between drawing power from the cells (52I, 52II) as a function of pre-set parameters or received instruction.

**2.** A battery-powered parcel locker (10) according to claim 1, wherein

- the parcel locker controller (40) is configured to send instruction to the cell switch (60) as a function of the pre-set parameters or received instruction; or
- the cell switch (60) comprises a switch energy source (62) powering a switch controller (64) configured to cause the cell switch (60) to switch between drawing power to the cells (52I, 52II) as a function of the pre-set parameters or received instruction.

**3.** A battery-powered parcel locker (10) according to claim 1 or 2, wherein the parcel communication module (30) comprises one or more of the following

- a Bluetooth communication module, preferably

a Bluetooth low-energy communication module;
- a numpad for providing a code;
- NFC module for receiving instructions;
- a microphone for receiving instructions;
- a ZigBee module;
- a GSM module; or
- a WiFi module.

**4.** A battery-powered parcel locker (140) according to anyone of claims 1 to 3, wherein the batteries (54) are primary batteries such as a wet type battery preferably Li-SoCl2 batteries, or manganese batteries, or iron disulfate (LiFeS2) batteries, lithium manganese dioxide (LiMnO2) batteries, or lithium metal-oxide batteries, or high impedance batteries.

**5.** A battery-powered parcel locker (10) according to anyone of claims 1 to 4, wherein the battery-powered parcel locker (10) further comprises one or more voltage comparators (70) configured for comparing cell voltage with a reference voltage.

**6.** A battery-powered parcel locker (10) according to anyone of claims 1 to 5, wherein the parcel locker (10) comprises a super capacitor (56) configured for powering at least the two or more lock units (24) and optionally the parcel locker controller (40) and the parcel communication module (30); wherein the battery unit (50) is configured for charging the super capacitor (56).

**7.** A battery-powered parcel locker (10) according to anyone of claims 1 to 6, wherein the parcel locker (10) comprises a thermistor (58) between the battery unit (50) and the two or more lock units (24).

**8.** A battery-powered parcel locker (10) according to anyone of claims 1 to 5, wherein the battery unit (50) comprises a lock unit battery cell (53) configured to power the two or more lock units (24), wherein the parcel locker controller (40) is configured to control powering of the two or more lock units (24) and the lock unit battery cell (53) comprises one or more batteries (54).

**9.** A battery-powered parcel locker (10) according to claim 8, wherein the one or more batteries (54) comprise one or more manganese batteries.

**10.** A method (1000) for switching battery cells of a battery-powered parcel locker (10) including two or more lock units (24) adapted for providing access to a compartment (22) as a function of received instructions, wherein the method comprises steps of

- providing (1100) a battery-powered parcel locker (10) comprising two or more cells (52I, 52II) comprising one or more batteries (54), wherein each cell is dimensioned and configured to power the parcel locker (10);
- switching (1200) between the two or more cells (52I, 52II) as a function of pre-set parameters or received instruction.

**11.** A method (1000) according to claim 10, wherein the pre-set parameters are chosen among numbers of actions performed at the parcel locker (10) or a pre-set period or energy consumption or a combination.

**12.** A method (1000) according to claim 10 or 11, wherein at least one of the batteries (54) are being primary batteries such as a wet type battery and preferably Li-SoCl2 batteries, or manganese batteries, or iron disulfate (LiFeS2), lithium manganese dioxide (LiMnO2), or lithium metal-oxide, or high impedance batteries.

**13.** A method (1000) according to anyone of claims 10 to 12, wherein the battery-powered parcel locker (10) comprises two or more lock unit battery cells (53I, 53II) configured to powering lock units (24) during unlocking, wherein each lock unit battery cells (53I, 53II) comprise one or more manganese batteries and the step of switching (1200) includes switching between the two or more lock unit battery cells (53I, 53II) as a function of the pre-set parameters or instructions.

**14.** A method (1000) according to anyone of claims 10 to 13, wherein the method further comprises steps of

- comparing (1400) a voltage of one of the cells (52I, 52II, 53I, 5311) with a reference voltage; and

- sending (1500) an alarm as a function of the step of comparing (1400); and/or
- removing (1600) the battery cell (1400) from the switching cycle.

**15.** A battery-powered parcel locker (10) comprising

- two or more compartments (20), wherein each of the two compartments (20) comprises a gate (22) with a lock unit (24) for controlling access to the compartment;
- a parcel communication module (30) for receiving instructions;
- a parcel locker controller (40) comprising at least one processor and at least one memory that includes program code, wherein the memory and the program code is configured to cause the processor to instruct the two or more lock units (24) to open as a function of received instructions;
- a battery unit (50) for powering at least the par-

cel locker controller (40), the parcel communication module (30), and the two or more lock units (24); wherein the battery unit (50) comprises a first cell (52I) equipped with one or more batteries (54), a second cell (52II) equipped with one or more batteries (54), the cells (52I, 52II) being in a parallel configuration, wherein the batteries (54) are primary batteries and the batteries (54) define a non-destructive current direction, wherein each cell (52I, 52II) comprises a diode (59I, 59II) preventing current flow reverse to the non-destructive current direction.

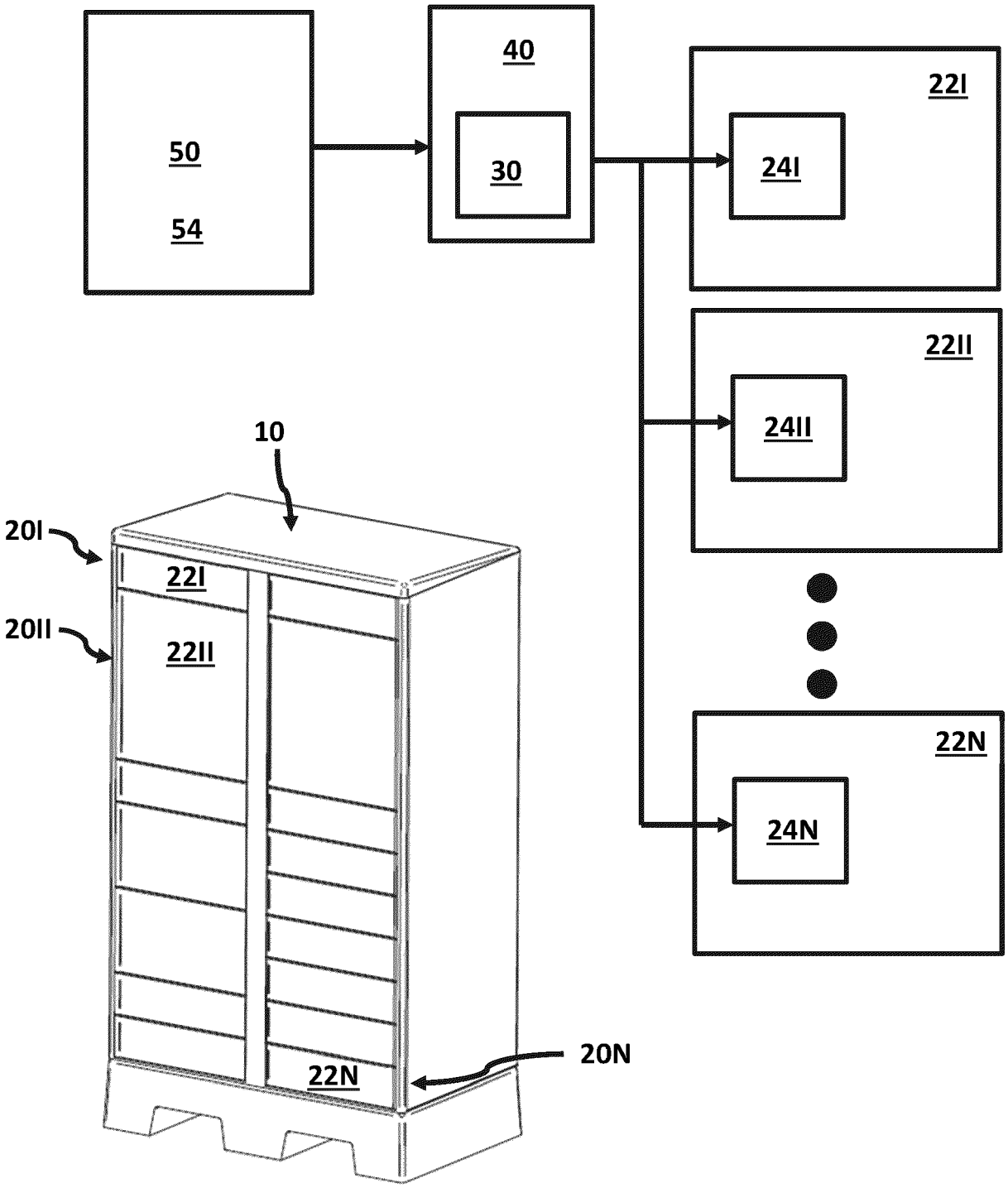
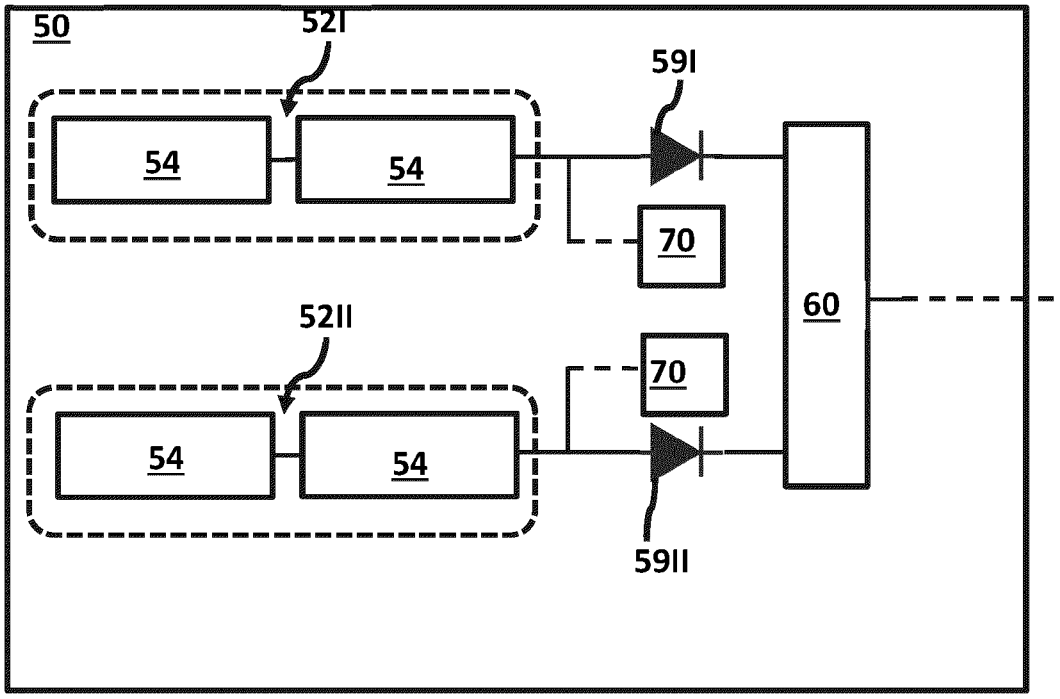

50
54
40
30
22I
24I
22II
24II
22N
24N
10
20I
22I
20II
22II
20N
22N

Fig. 1

A: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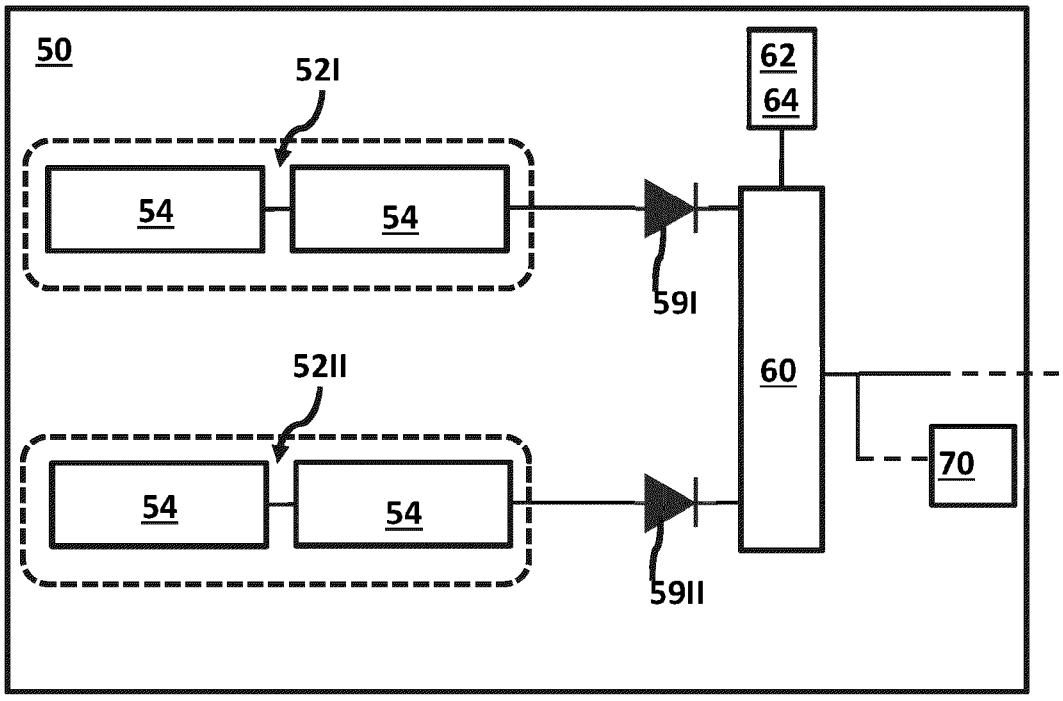
52I
59I
54
54
70
60
52II
70
54
54
59II

B: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64
54
54
59I
60
52II
70
54
54
59II

Fig. 2

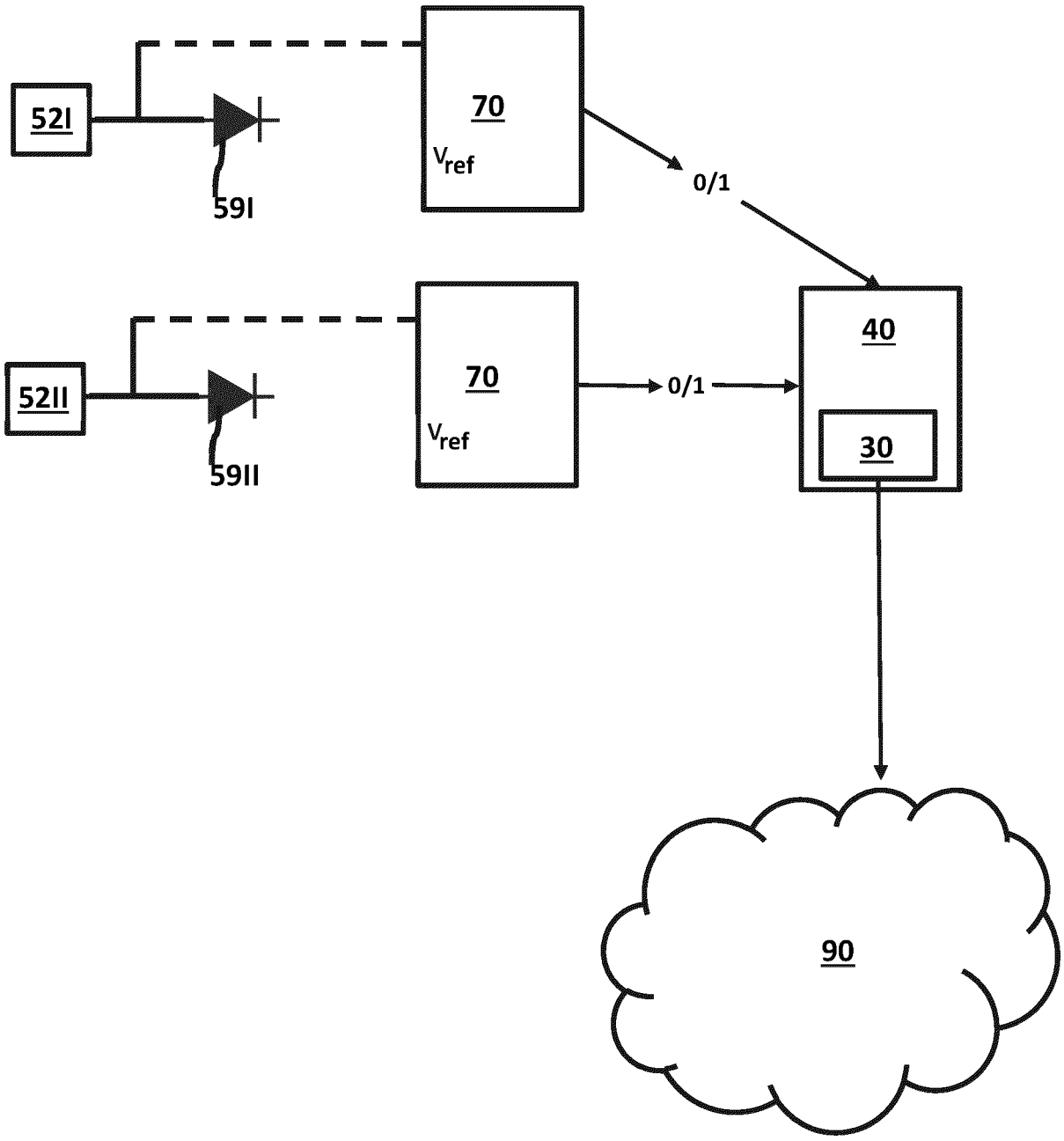


Fig. 3

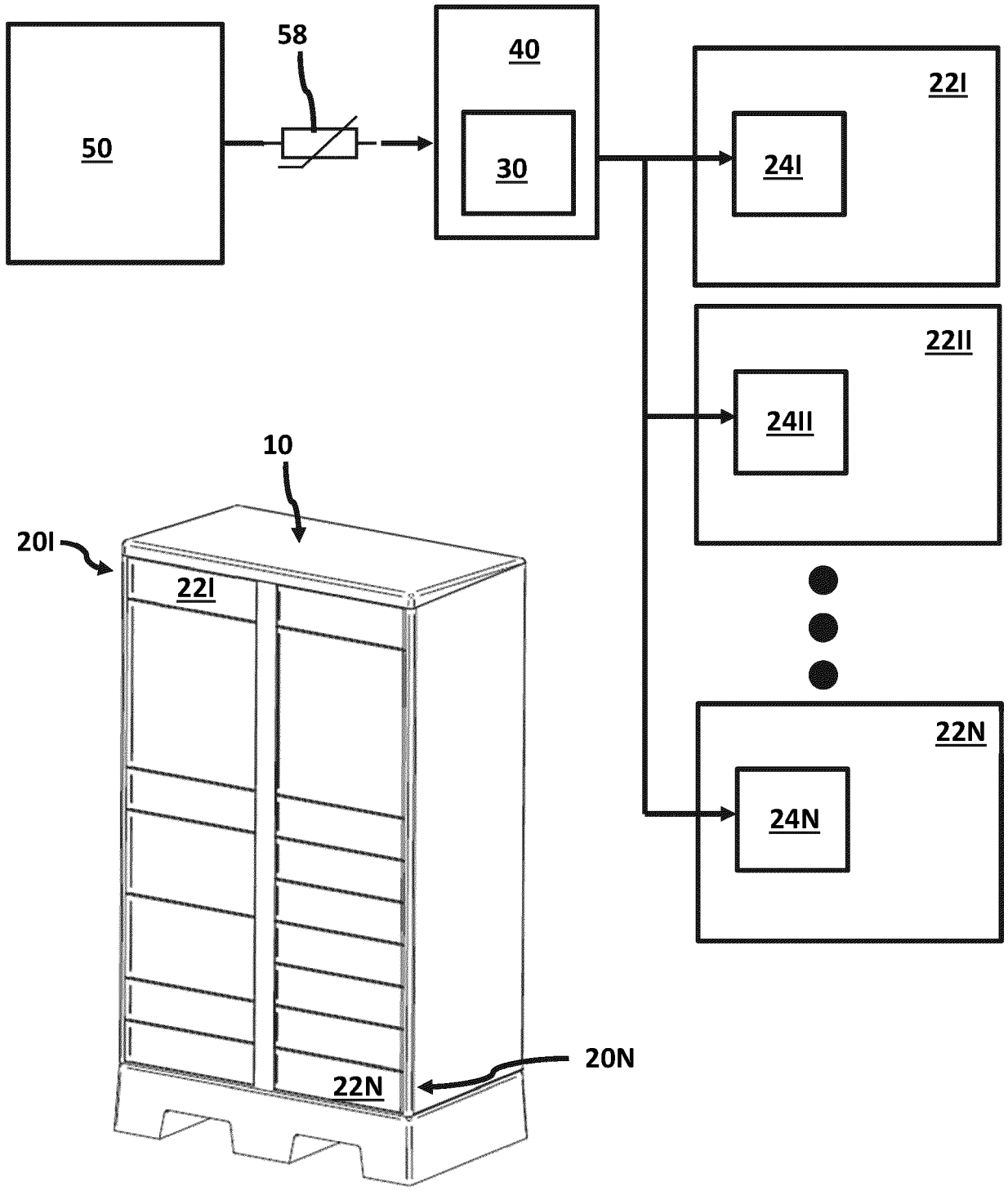


Fig. 4

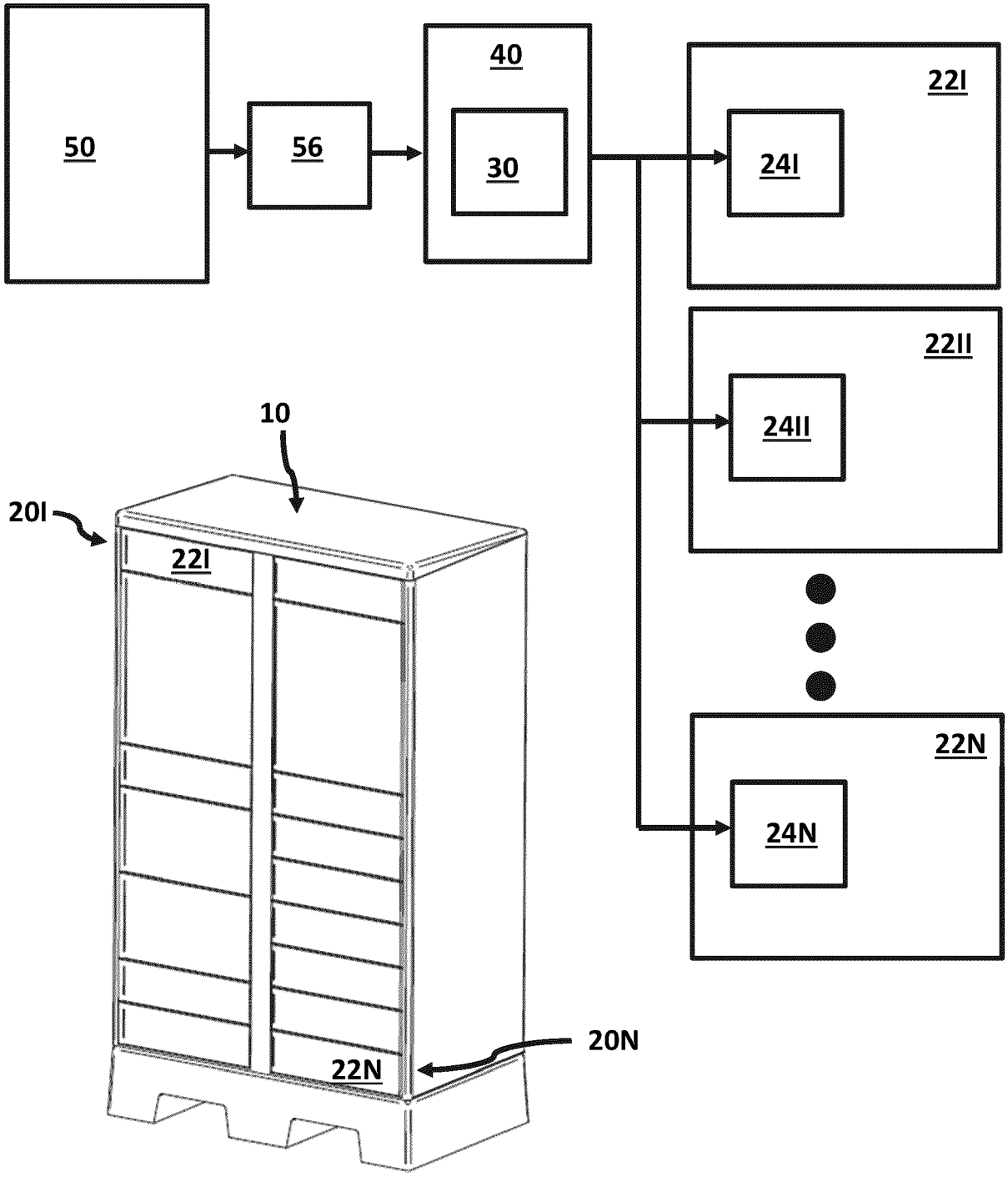


Fig. 5

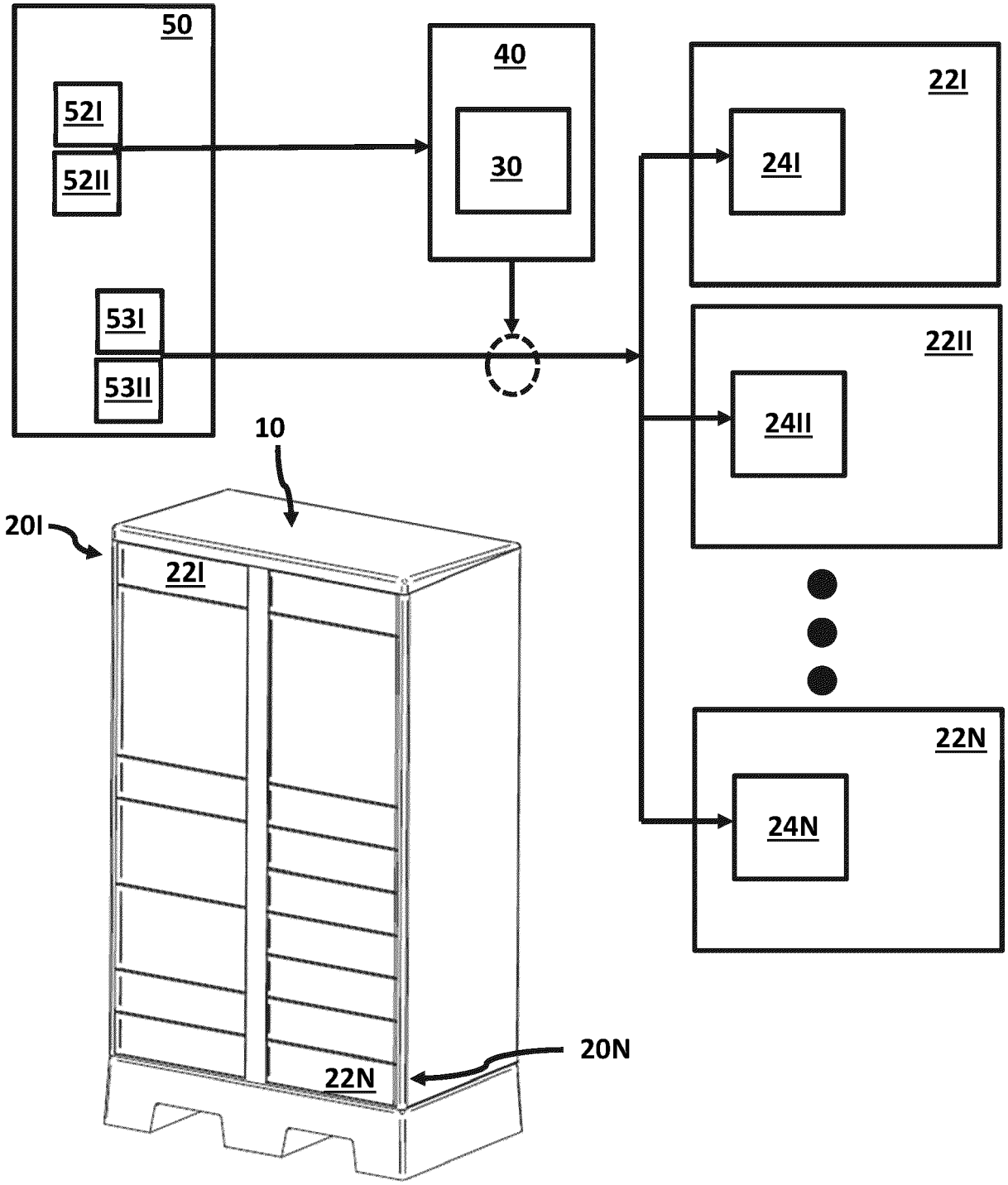
50
52I
52II
53I
53II
40
30
22I
24I
22II
24II
22N
24N
10
20I
22I
22N
20N

Fig. 6

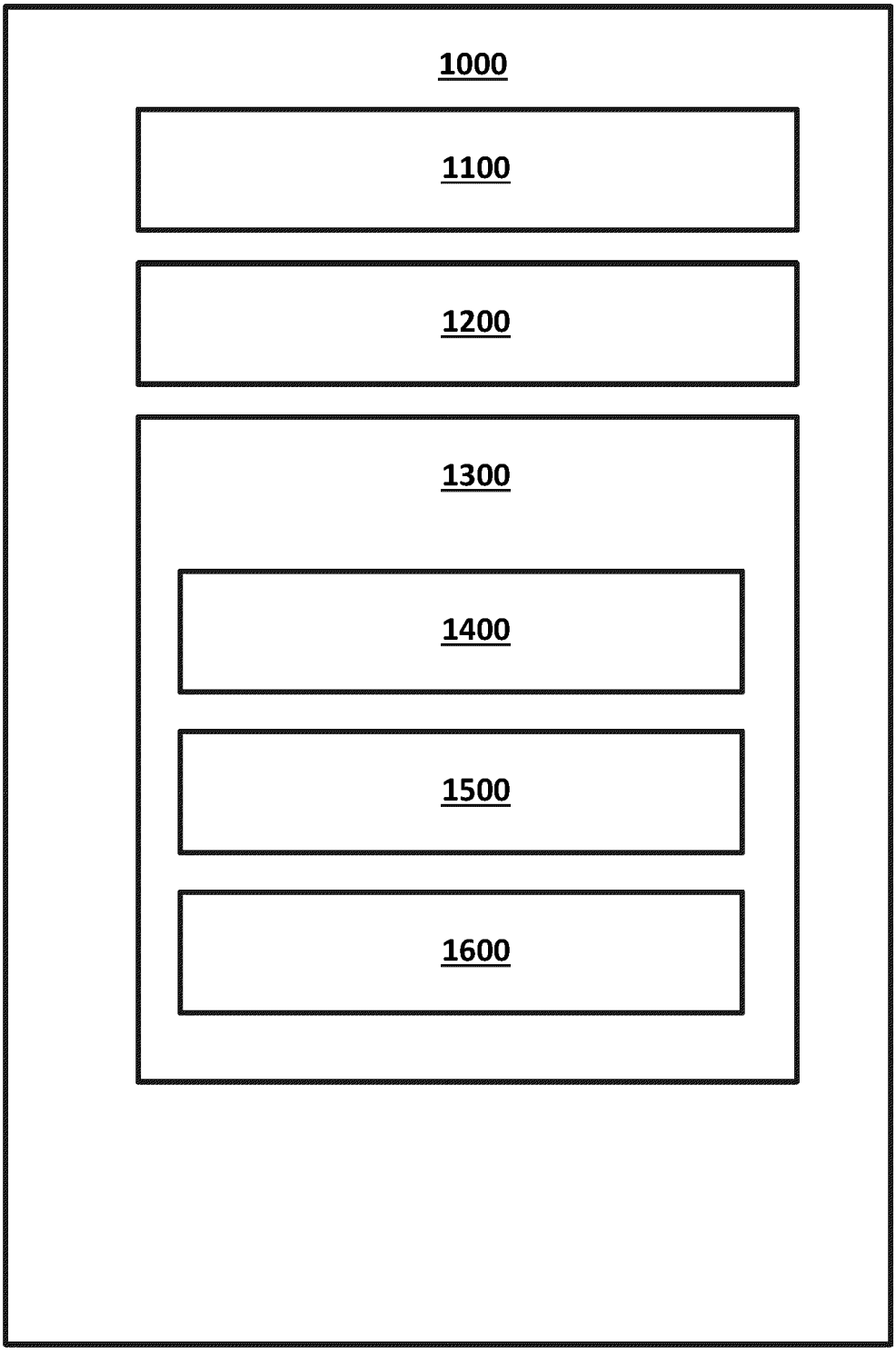


Fig. 7

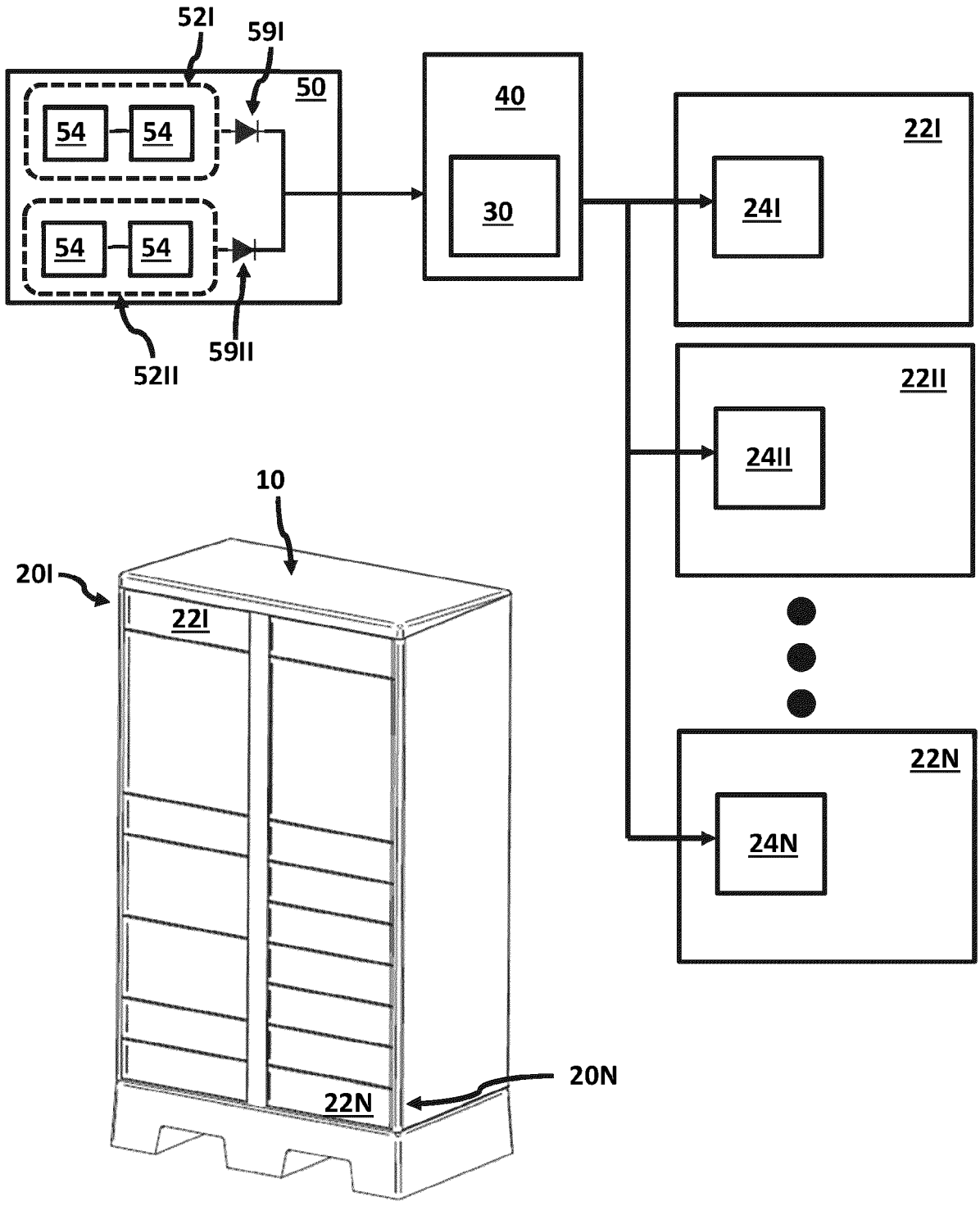
52I
59I
50
54
54
54
54
52II
59II
40
30
22I
24I
22II
24II
22N
24N
10
20I
22I
22N
20N

Fig. 8

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Application Number
EP 23 15 2160

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H02J
A47G
G07F

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| The Hague | 6 June 2023 | Longo dit Operti, T |

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