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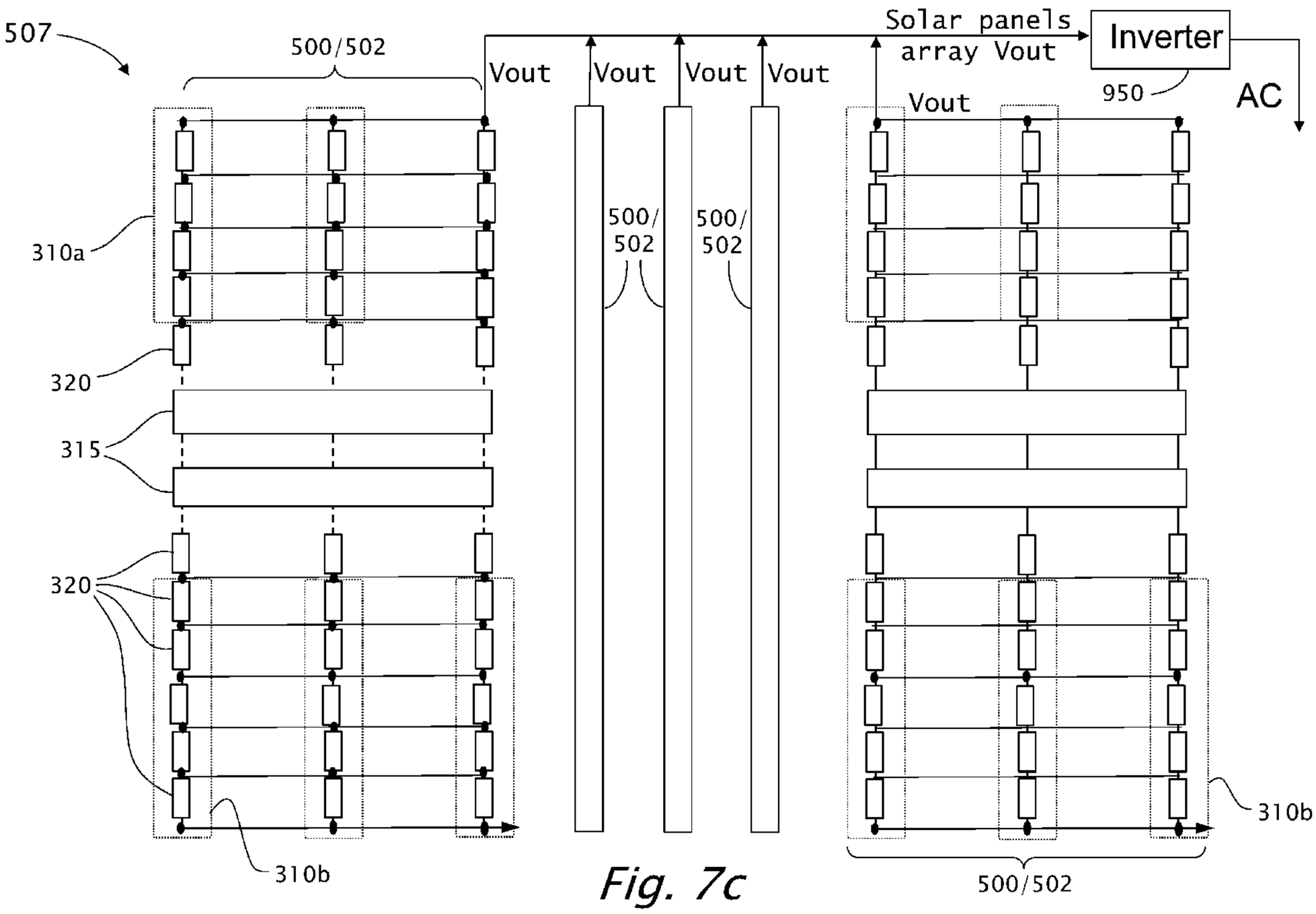


Fig. 7c

(57) Abrégé/Abstract:
A solar power generation system for providing a predetermined operating power level and predetermined operating voltage level requirement, the system including at least one solar-array panel, wherein each of the at least one solar-array panels includes a

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(57) Abrégé(suite)/Abstract(continued):
multiplicity of PV solar sub cells, wherein a preconfigured number of the PV solar sub cells are electrically connected in series to form a serial-unit or each individual serial unit having just one PV solar sub cell, and wherein a preconfigured number of the serial units are electrically connected in series to form a string of serial-units. The PV solar sub cells are also connected in parallel to neighboring sub cells to form a crisscross matrix array that facilitates bypassing malfunctioning serial units, thereby improving the performance of the system. A PV solar sub cell is at least 50% smaller in area than a regular PV solar cell.

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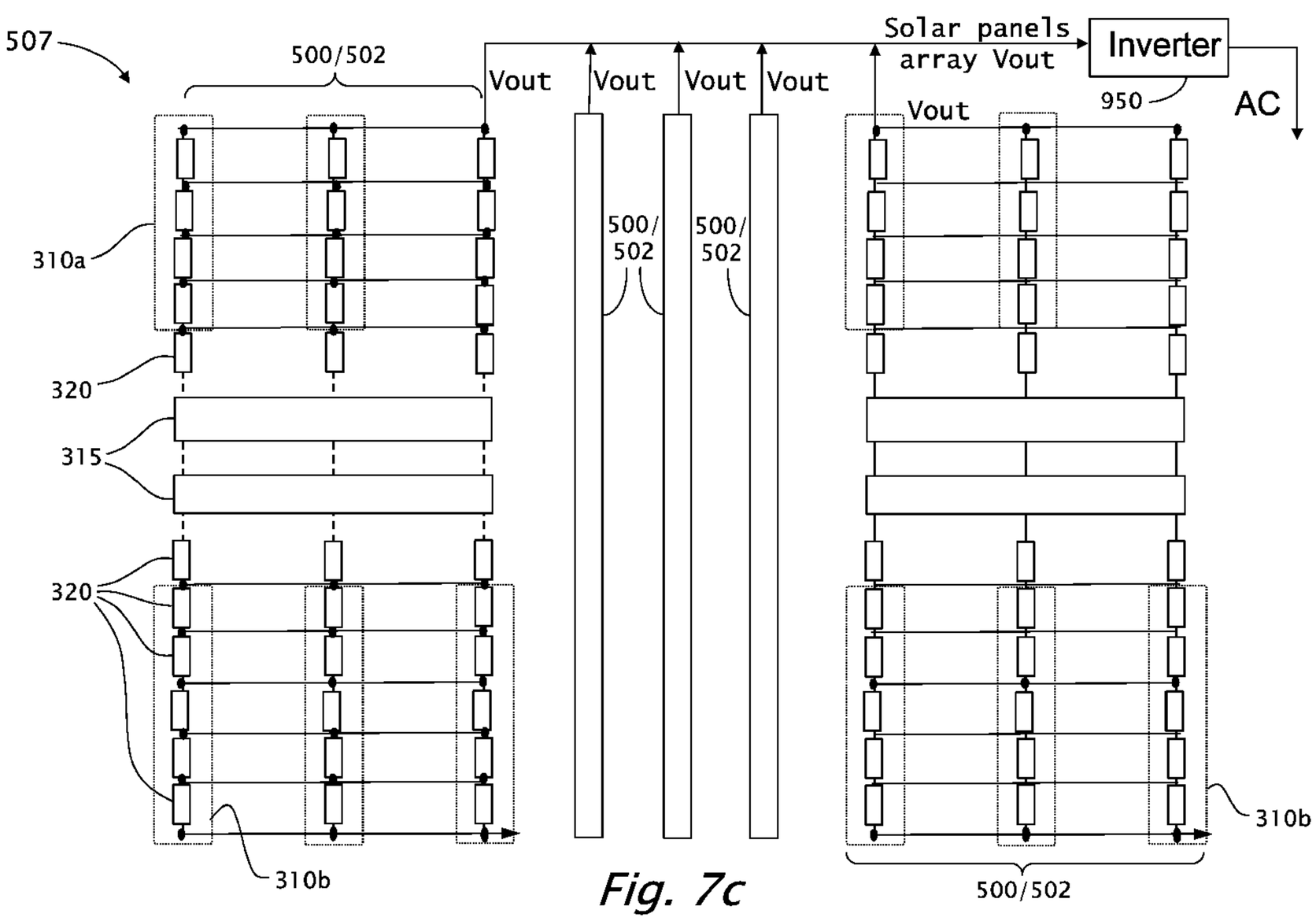


Fig. 7c

(57) Abstract: A solar power generation system for providing a predetermined operating power level and predetermined operating voltage level requirement, the system including at least one solar-array panel, wherein each of the at least one solar-array panels includes a multiplicity of PV solar sub cells, wherein a preconfigured number of the PV solar sub cells are electrically connected in series to form a serial-unit or each individual serial unit having just one PV solar sub cell, and wherein a preconfigured number of the serial units are electrically connected in series to form a string of serial-units. The PV solar sub cells are also connected in parallel to neighboring sub cells to form a crisscross matrix array that facilitates bypassing malfunctioning serial units, thereby improving the performance of the system. A PV solar sub cell is at least 50% smaller in area than a regular PV solar cell.

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SOLAR MODULES HAVING SOLAR SUB CELLS WITH MATRIX CONNECTIONS BETWEEN THE SOLAR SUB CELLS

FIELD OF THE INVENTION

The present invention relates to a solar array module system for generating electric-power and more particularly, to a non-monolithic solar array module system having PV solar sub cells interconnected in a crisscross configuration.

BACKGROUND OF THE INVENTION

Non-monolithic photovoltaic (PV) cells that are subdivided into smaller sub cells that are interconnected in series, are known in the art.

Solar array modules, having solar cells that are interconnected in a crisscross electrical matrix are also known in the art. See, for example, PCT Published Application No. WO/2011/089607 ('607) filed on January 23rd, 2011, and PCT Published Application No. WO/2013/144963 ('963) filed on March 30th, 2013, by the same inventor as the instant application and which is owned in common, which are hereby incorporated by reference in their entirety.

The electrical current generated in a PV cell brings about losses of power caused by:

1. The busbar of each solar cell.
2. The solder points between PV cells and external conductors and other soldered points.
3. Conductors interconnecting PV cells into string of cells.
4. Conductors connecting string of PV cells to respective junction boxes.

These overall power losses decrease the output power of a PV panel.

A typical non-monolithic PV panel consists of dozens of quadratic PV cells. A typical quadratic cell size is approximately 15cm X 15cm and provides electrical power of around (all numbers are given by way of example only, with no limitations):

$$0.5V * 8A = 4W$$

With reference to the drawings, Fig. 1., showing the equivalent circuit **20** of a PV cell, it is evident that the current ***I*** **(80)** produced by the solar cell is equal to that produced

by the current source **70**, minus that which flows through the diode **30**, minus that which flows through the shunt resistor **40**:

$$I = I_L - I_D - I_{SH}$$

where

- I (**80**) = output current (ampere)
- I_L (**82**) = photo-generated current (ampere)
- I_D (**84**) = diode current (ampere)
- I_{SH} (**86**) = shunt current (ampere).
- R_S (**50**) << R_{SH} (**40**)

The values of I_L, I_D, R_S and R_{SH} are dependent upon the physical size of the solar cell. When comparing otherwise identical technology solar cells, a first cell with twice the junction (light sensitive) area of a second cell generates double the I_L and I **80** is also approximately twice higher.

Regardless of the PV cell size, the cell output voltage **60** remains almost unchanged.

For example, if instead of a regular 15cm X 15cm (proximal dimensions) quadratic cell, herein after also referred to as "regular size solar cell", "regular PV solar cell", "regular solar cell", or "regular cell", two cells of size 15cm X 7.5cm, or three cells of size 15cm X 5cm each are used (or other smaller (sub) sizes of cells that combine into a total of 15cm X 15cm area, thereby the power of the regular 15cm X 15cm quadratic cell and the sum of the combined sub cells' power are equivalent (not considering smaller power losses and improved fill-factor of sub-cells, because actually, they provides higher power yield), then: the smaller size cell of 15cm X 7.5cm produces a voltage of around 0.5V, but provides half the magnitude of current of the big cell (15cm * 15cm), i.e., I = 8A / 2 = 4A.

Similarly, a sub cell of 15cm X 5cm provides a current I = 8A / 3 = 2.66A. Therefore, the power losses caused by the three times smaller size solar cell output current on the same soldering points of cells, same busbars on solar cells, same conductors interconnecting PV cells to strings of cells, same conductors connecting strings of PV cells to designated junction boxes, according to the following expression, will be significantly less than the power losses brought about by larger output current of the bigger size cell:

$$P_{lusses} = I^2R,$$

where R is total resistance of all of the above conductors and soldered points.

The table below compares, by way of example, the power losses in 250W panel with big and small PV cells sizes:

PV cell size	I (A)	Total power losses (W) according paragraph 1	Amount of power losses (W) saved
156mm X 156mm	8	11	**9**
156mm X 52mm	2.66	2	

Incorporating smaller size cells with cells matrix connection maintains all advantages of this type of cells connection and provide higher power yield from each cell and from the entire panel.

There is therefore a need and it would be advantageous to have solar array modules for producing electric-power, having solar cells that are interconnected in a crisscross electrical matrix, wherein at least some of the regular size solar cells are "replaced" by a number of equivalent sub cells, and it would be further advantageous to have at least some of the sub cells interconnected in matrix, crisscross configuration. Typically, with no limitation, a regular size solar cell is cut into the number of equivalent sub cells.

SUMMARY OF THE INVENTION

A principal intention of the present invention is to provide a non-monolithic array of solar cells that are interconnected in a crisscross electrical matrix, wherein at least some of the regular size solar cells are replaced by a number of sub cells that provide the same voltage, and wherein the smaller the solar cells are the less power losses are inflicted. The crisscross electrical matrix provides a passive rerouting of electric current when an individual solar-cell malfunctions. The solar module includes solar cells that are interconnected in a crisscross electrical matrix, wherein at least some of the "regular" size solar cells (15cmX15cm) are, for example, replaced by cutting such a regular size solar cell into a number of equivalent sub cells, and wherein the sub cells are interconnected in matrix, crisscross configuration.

Let us presume, for example, with no limitations, a common panel having 60 regular (15cmX15cm) PV solar cells **210**, that is arranged in a crisscross matrix configuration of 10 columns with serial strings each consisting of 6 regular PV solar cells. Each serial string of cells **210** provides power of: 8A * (0.5V*6) = 24W. Hence, the voltage of a serial string of regular cells **210** is: 0.5V*6 = 3V, and the panel provides a total of 240W. It should be noted that a 3V panel voltage is not suitable to obtain the voltage of commonly used regular panels, and requires an additional voltage DC/DC converter **250** (see Fig. 3) to boost the panel output voltage. If each regular PV solar cells **210** is replaced by a string of 9 sub cells, connected in serial, each typically of size 15cmX1.67cm, then the current ***I*** drops to 8/9 = 0.8889A, but the voltage of serial string of sub cells is now: 0.5V*6*9 = 27V. Therefore, the total output power remains 240W. In such a case, no DC/DC converter **250** is needed and it is possible to connect all panels with crisscross matrix cells connections, with or without a Maximum Power Point Tracker (being a power optimizer), directly in series to create strings of panels, to connect strings in parallel and to connect directly to an inverter or create parallel connections of a lot of the above panels with suitable panels output voltage and connect this array to battery charger with or without a MPPT.

The advantages of multiple sub cells arranged in a crisscross matrix include:

a. No DC/DC converter **250** is needed, thereby reducing the panel cost.
b. Lack of need to use voltage converter enables to increase the panel energy by about 3% (in case of a 97% efficiency of converter).
c. The smaller current of the PV cells further reduces power losses.

It should be noted that orientation related descriptions such as “top”, “bottom”, “horizontal”, “vertical” “up”, “upper”, “down”, “low”, “lower” and the like, assumes that the solar cell module is situated, with no limitations, such that the positive (“+”) side of the array is considered, artificially, with no limitations, as the top side of the array, and the negative (“-”) side of the array is considered, artificially, with no limitations, as the bottom side of the array. Alternatively, with no limitations, the negative (“-”) side of the array is considered, artificially, with no limitations, as the top side of the array, and the positive (“+”) side of the array is considered, artificially, with no limitations, as the bottom side of the array.

It should be further noted that the terms "electrical" or "electrically wired", as used herein refer to the electrical configuration of the matrix, regardless of the physical configuration of the solar cells in the solar panel. Similarly, it should be further noted that the term "physical" as used herein refers to the physical placement of solar cells in the module/panel, regardless of the electrical inter-wiring of the solar cells.

According to the teachings of the present invention there is provided a solar power generation system for providing a predetermined operating power level and predetermined operating voltage level requirement, the system including at least one solar-array panel, wherein each of the at least one solar-array panels includes a multiplicity of PV solar sub cells, wherein a preconfigured number of the PV solar sub cells are electrically connected in series to form a serial-unit or each individual serial unit having just one PV solar sub cell, and wherein a preconfigured number of the serial units are electrically connected in series to form a string of serial-units, the string of serial-units is facilitated to produce a first output voltage level.

A preconfigured number of the strings of serial-units, are electrically connected in parallel to form an array of the PV solar sub cells. In each of the strings of serial-units, each of the serial-units is also connected in parallel to the neighboring serial-units of all other strings of serial-units, to form a crisscross matrix array of the serial units, the crisscross matrix array of the PV solar sub cells is facilitated to produce a first output power level, wherein the crisscross matrix array of the serial units allows currents to bypass malfunctioning serial units, thereby improving the performance of the system; and

Each of the PV solar sub cell is physically smaller than a regular PV solar cell, wherein a regular PV solar cell is a quadrangular of about 15cmX15cm and produces a voltage of about 0.5V and current of about 8A, and wherein the PV solar sub cell is a quadrangular PV solar cell that is at least 50% smaller in area than a regular PV solar cell.

It should be noted that the voltage produced by a regular PV solar cell and by a combination of the PV solar sub cell, covering an equivalent PV area, is the same, but the current generated by the combination of the PV solar sub cell is directly proportionately smaller than the current generated by a regular PV solar cell, thereby minimizing power loses and eliminating the need for a DC/DC converter.

Optionally, each of the strings of serial-units consists of the same number of the solar cells electrically connected in series.

Optionally, the solar power generation system further including a quantity of f bypass diodes that are connected in parallel to a preconfigured number of rows of the sub cells of the matrix array of the solar-array panel.

Optionally, the sub cells are formed by cutting regular PV solar cell.

Optionally, the multiple solar-array panels are connected in parallel and coupled to operate with a panel DC/AC inverter, to invert the DC output voltage of aid solar-array panels to AC voltage.

Optionally, the array parallelly connected solar-array panels are further connected in serial with a battery charger. Preferably, the battery charger is coupled to operate with a maximum power point tracker (MPPT) optimizer, and wherein the multiple solar-array panels are connected in parallel.

Optionally, the multiple solar-array panels are serially connected to form a string of solar-array panels, wherein the multiple strings of solar-array panels are connected in parallel, and wherein the array of multiple strings of solar-array panels are connected in parallel is further serially connected with a DC to AC inverter.

Optionally, the DC output of the matrix array of the PV solar sub cells is regulated by a MPPT optimizer, to provide maximum yield of power from the solar matrix array panel of the system. Optionally, a communication unit facilitates communication between the MPPT optimizer and a remote computerized unit.

Optionally, each of the string of solar-array panels is serially connected with a DC to AC inverter, before being parallelly interconnected.

Optionally, the DC output of the matrix array is serially connected to an inverter that inverts the DC voltage to AC voltage.

Optionally, the solar power generation system further includes a MPPT optimizer, an input/output voltage/current measurement unit and a power-calculation-processor, wherein the maximum power point (MPP) of the crisscross matrix of sub solar cells is regulated by the MPPT optimizer, based on the voltage/current measurements obtained by

the measurement unit and analyzed by the power-calculation-processor. Optionally, the solar power generation system further includes a central monitoring and control sub system having a central processor, wherein the matrix array panel further includes a transmitter and a receiver, wherein the transmitter is configured to transferring the measurement data obtained from input /output voltage/current meter to a central processor; wherein the receiver is configured to receive commands from the central processor; and wherein the power-calculation-processor is configured to provide the MPPT optimizer with regulation data to thereby regulate the MPP of the crisscross matrix of sub solar cells.

Optionally, the central processor is further configured to send and/or receive data to and/or from a remote processor.

Optionally, the remote processor is selected from a group including a remote computer and a smart mobile device.

Optionally, the data is selected from a group including panel energy, power, temperature, voltage, current, time and date, a disable command and an enable command.

Optionally, the multiple solar-array panels that are MPP regulated, are serially connected to form a string of solar-array panels, and wherein the multiple strings of solar-array panels are connected in parallel.

Optionally, the multiple solar-array panels, that are MPP regulated, connected in parallel. Optionally, each of the solar-array panels is serially connected in series with a DC to AC inverter, before being interconnected in parallel.

Optionally, each of the solar-array panels is serially connected with a DC to AC inverter, and wherein the solar-array panels are connected in parallel before being serially connected with the DC to AC inverter and after being serially connected with the DC to AC inverter. Optionally, the parallel connection of the solar-array panels, before being serially connected with the DC to AC inverter, is switchable.

Optionally, the solar power generation system further includes a central monitoring and control sub system having a central processor, wherein each of the matrix array panel further includes a processor, output/input voltage/current measurement, transmitter and a receiver, wherein the transmitter is configured to transferring the

measurement data obtained from input/output voltage/current meter to a central processor; wherein the receiver is configured to receive commands from the central processor; and wherein the power-calculation-processor is configured to provide the MPPT optimizer with regulation data to thereby regulate the MPP of the crisscross matrix of sub solar cells of the matrix array panels.

Optionally, the DC output of the matrix array is connected to a DC/DC power converter.

Optionally, the DC output of the matrix array is connected to multiple DC/DC power converters.

Optionally, the DC output of each of the strings of serial-units of the matrix array is serially connected to a DC/DC power converter, and wherein the parallelly connected DC/DC power converters are serially connected to a MPPT.

Optionally, the DC output of each of the strings of serial-units of the matrix array is serially connected to a DC/DC power converter, wherein each the DC/DC power converters is serially connected to a respective MPPT.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will become fully understood from the detailed description given herein below and the accompanying drawings, which are given by way of illustration and example only, and thus not limiting in any way, wherein:

Fig. 1 (prior art) is a schematic illustration of the equivalent electrical circuit of a PV cell.

Fig. 2 (prior art) is a schematic illustration of a solar cell matrix having regular PV solar cells interconnected in a crisscross configuration.

Fig. 3 (prior art) is a schematic example of a solar cell module, wherein a DC to DC voltage converter is connected to the output of the solar cell matrix shown in Fig. 2.

Fig. 4 (prior art) illustrates current-voltage characteristics of a typical solar array module, with various cell temperatures and various irradiance levels, including voltage range of maximum power point regulation zone.

Fig. 5a is a schematic illustration of an example solar cell matrix having PV cell units interconnected in a crisscross configuration, according to some embodiments of the present invention, wherein each PV cell unit consists of 3 PV sub cells.

Fig. 5b is a schematic illustration of another example solar cell matrix having PV cell units interconnected in a crisscross configuration, according to some embodiments of the present invention, wherein each PV cell unit consists of 3 PV sub cells.

Fig. 6 is a schematic illustration of another example of a solar sub cells matrix, wherein each PV cell unit consists of at least one PV sub cell, interconnected in a crisscross matrix configuration of M rows and N columns, according to some embodiments of the present invention.

Fig. 7a is a schematic illustration of an example solar cells panel, wherein the matrix of the solar sub cells of the panel is, for example with no limitations, similar to the solar cell matrix shown in Fig. 6.

Fig. 7b is a schematic illustration of an example of a solar cells panel shown in Fig. 7a, wherein two rows of sub cells are shaded, and wherein one or more bypass diodes are connected, when each diode bypasses one or more respective rows of solar cell units.

Fig. 7c is a schematic illustration of an example solar panels array (each panel, in this example, is similar to solar cell matrix panel shown in Fig. 7a), wherein the panels are connected in parallel, and wherein the solar array panels array is coupled with a panel DC/AC inverter, to invert the DC output voltage of the solar matrix array panel to AC voltage, for example to 220V or 110V, according to embodiments of the present invention.

Fig. 7d is a schematic illustration of an example solar panels array, similar to the array of solar panels shown in Fig. 7c, but the array is serially connected to the input of a battery charger with maximum power point tracker (MPPT).

Fig. 8a is a schematic illustration of an example solar matrix array panel coupled with a power optimizer having a MPPT device, to provide maximum yield of power from the solar matrix array panel, according to embodiments of the present invention.

Fig. 8b is a schematic illustration of another example solar matrix array panel coupled with a power optimizer having a MPPT device and a communication unit, to form a monitoring and controlled solar matrix array panel, according to embodiments of the present invention.

Fig. 8c is a schematic illustration of another example solar matrix array panel coupled with a panel DC/AC inverter, to invert the DC output voltage of the solar matrix array panel to AC voltage, for example to 220V or 110V, according to embodiments of the present invention.

Fig. 8d is a schematic illustration of another example of an array of parallelly connected strings of solar panels array, as shown, with no limitations in Fig. 7c, wherein each string of solar panels array is serially coupled with a panel DC/AC inverter that is connected in parallel in their AC outputs, according to embodiments of the present invention.

Fig. 9 is a schematic illustration showing an example of a solar-array module, including an array of crisscross network of solar sub cells and a MPPT optimizer, an input/output voltage/current measurement unit, a processor for power calculations.

Fig. 10 is a schematic illustration showing an example of a solar-array module, including an array of crisscross network of solar sub cells and a MPPT optimizer, an input/output voltage/current measurement unit, a processor, a transmitter and a receiver, for transferring measurement data from a solar-array module to the general system central controller (CC) and for transferring CC commands to each solar-array module and optionally, providing information to a remote computer or a remote smart mobile device of each panel or an entire system.

Fig. 11a is a schematic illustration showing an example solar-array system, having several strings of solar-array modules that are connected in parallel, wherein each solar-array module includes a MPPT optimizer and an array of solar cell units having “n” PV sub cells connected in a crisscross configuration.

Fig. 11b is a schematic illustration showing an example solar-array system, having several solar-array modules that are connected in parallel, wherein each solar-array module includes a MPPT optimizer and an array of solar cell units having “n” PV sub cells connected in a crisscross configuration.

Fig. 12a is a schematic illustration showing another example solar-array system, having several strings of solar-array panels that are connected in parallel, wherein each solar-array module includes a MPPT optimizer, communication device and an array of solar cell units having “n” PV sub cells connected in a crisscross configuration, and wherein all solar-array modules are controlled by a central monitoring and control system and transmits data to customer PC or mobile phone.

Fig. 12b is a schematic illustration showing another example of a solar-array system, having several solar-array panels that are connected in parallel, wherein each solar-array module includes a MPPT optimizer, communication device and an array of solar cell units having "n" PV sub cells connected in a crisscross configuration, and wherein all solar-array modules are controlled by a central monitoring and control system and transmits data to customer PC or mobile phone.

Fig. 13a is a schematic illustration showing an example solar-array system, having for example m * nsolar-array panels, wherein each panel includes a crisscross matrix of PV sub solar cells, and wherein the solar-array system includes a DC/AC inverter.

Fig. 13b is a schematic illustration showing an example solar-array system, having for example "n" solar modules when each one consists of solar panel equipped by MPPT optimizer and Communication devices, wherein each panel includes a crisscross matrix of PV sub solar cells, and wherein the DC/AC inverter is connected to each module.

Fig. 13c is a schematic illustration showing an example solar-array system, having for example "n" solar modules when each one consists of solar panel equipped by MPPT optimizer and communication devices, wherein each panel includes a crisscross matrix of PV sub solar cells, and wherein the DC/AC inverter is connected to each module. Furthermore, in this example, the solar modules are parallelly interconnected.

Fig. 13d is a schematic illustration showing an example solar-array system, having for example "n" solar modules when each one consists of a solar panel equipped by MPPT optimizer and communication device, wherein each panel includes a crisscross matrix of PV sub solar cells, and wherein the DC/AC inverter connects to each module. Furthermore, in this example, the solar modules are parallelly interconnected, wherein the connections in the parallel DC inputs are controllably switchable, according to embodiments of the present invention.

Fig. 14 is a schematic illustration of an example solar cell module, wherein a DC to DC voltage converter is connected to the output of the solar cell matrix shown in Fig. 5b, according to some embodiments of the present invention.

Fig. 15 is a schematic illustration of another example solar cell module, wherein a number of DC to DC voltage converters are connected to the output of the solar cell matrix shown in Fig. 5b, according to some embodiments of the present invention.

Fig. 16 is a schematic illustration of another example solar cell module, wherein a number of DC to DC voltage converters are connected to the output of the solar cell matrix, as shown in Fig. 5b, and a MPPT device is connected to the output of the above converters with paralleled outputs, according to some embodiments of the present invention.

Fig. 17 is a schematic illustration of another example solar cell module, wherein a number of DC to DC voltage converters are connected to the output of the solar cell matrix, as shown in Fig. 5b, and a number of MPPT devices are connected to output each one of the above converters and the outputs of MPPT devices are paralleled, according to some embodiments of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown.

Reference is now made to the drawings. Fig. 2 shows a prior art schematic illustration of a solar cell matrix network **200** having regular PV solar cells **210** interconnected in a crisscross configuration. Fig. 3 (prior art) is a schematic example of a solar cell module **205**, wherein a DC to DC voltage converter **250** is connected to the output of solar cell matrix **200**. Such embodiments are described in '607. It should be noted that the DC to DC voltage converter **250** may be a push-pull converter, an UP converter, a forward converter, a maximum power point tracker (MPPT) device or other types of converters, or a combination thereof.

An aspect of the present invention is to provide a system that bring each solar-array module to work at the Maximum Power Point (MPP) to maximize power generation. The power produced by a solar array system is affected by the cell temperature, the load on the system and the level of irradiance. Fig. 4 depicts two graphs (**110**, **120**) of a solar module: current-voltage characteristics at various cell temperatures graph **110** and current-voltage characteristics at various irradiance levels graph **120**. In each of the graphs (**110**,

120), the width of the regulated zone (**114**, **124**) may differ significantly, for example, as a function of the shading conditions. In addition, in each of the graphs (**110**, **120**) the current remains generally steady as the voltage increases, until it drops down sharply at a certain voltage level, forming a knee-shaped curvature. At some point the knee is considered to have reached the Maximum Power Point (MPP) of the solar module. For example, at a radiance level of 1000W/m^2, the MPP is denoted by point **122** (approximately 28V); and at a temperature of 25°C, the MPP is marked by point **112** (approximately 25V). Hence, if the irradiance level or the temperatures are changed, the MPP changes and the output power decreases.

Fig. 5a is a schematic illustration of an example of a solar cell matrix network **300a** having serial unit **310** of PV subs cells **320** interconnected in a crisscross configuration, according to some embodiments of the present invention, wherein the combined PV area of each serial unit **310**, in this example, with no limitations, is equivalent to the PV area of a regular solar cell **210** (see Fig.3). In some embodiments, a regular size PV cell **210** is cut into the desired number of sub cells with similar dimensions.

Fig. 5b is a schematic illustration of another example of a solar cell matrix network **300b** having serial unit **310** of PV sub cells **320** interconnected in another crisscross configuration, according to some embodiments of the present invention, wherein the combined PV area of each serial unit**310**, in this example, with no limitations, is equivalent to the PV area of a regular solar cell **210**. In some embodiments, a regular size PV cell **210** is cut into the desired number of sub cells with similar dimensions.

In these example matrices **300**, it is shown that each regular cell (**210**) is subdivided into 3 (three) sub cells. It should be noted that if the total number of sub cells **320** in a matrix **300** is denoted by "***n***", the total number of sub cells **320** may be: 0<n<a myriad number.

Fig. 6 is a schematic illustration of another example solar cell matrix **400,** wherein each PV cell unit **310** consists of "***n***" PV sub cells **320**, wherein the number of sub cells **320** of matrix **400** may include any quantity "***n***" of sub cells **320**, and wherein the PV sub cells **320** are interconnected in a crisscross configuration.

In the crisscross configuration, a preconfigured number of PV solar sub cells **320**, being at least one PV solar sub cells **320**, are electrically connected in series to form a

serial unit **310**, wherein a preconfigured number of the serial units **310** are electrically connected in series to form a string of serial-units **330**, and wherein the string of serial-units **330** is adapted to produce a first output voltage level. The preconfigured number of strings of serial-units **330** are electrically connected in parallel to form the module array (**300**, **400**) of the PV solar sub cells **320**, wherein the module array (**300**, **400**) is adapted to produce a first output power level.

Furthermore, each serial-unit **310** of each of the strings of serial-units **330** is also connected in parallel to the neighboring serial-units **310** of all other strings of serial-units **330**, to form rows **315** of serial-units **310** and the crisscross matrix array (**300**, **400**) of serial units **310**. The crisscross matrix array (**300**, **400**) of the serial units (**310**) allows currents to bypass malfunctioning serial units **310**, thereby improving the performance of the matrix array (**300**, **400**) and the system thereof.

A matrix array (**300, 400**) may include a mix of rows **315** of various sizes of serial-units **310** of PV sub cells **320** connected serially. For example, Fig. 5a illustrates serial-units **310** of 3 (three) PV sub cells **320**; and Fig. 6 illustrates serial-units **310** of 4 (four) PV sub cells **320** as well as 5 (five) PV sub cells **320**.

Reference is now also made to Fig. 7a that schematically illustrates an example solar cells panel **500**, wherein the matrix of solar cell **310/320** of panel **500** is, for example with no limitations, similar to solar cell matrix **400**.

Fig. 7b, shows a solar panel **502** with partial shading, wherein two rows of sub cells **320s**are shaded. Solar panel **502** includes "n" PV sub cells interconnected in a crisscross configuration, as in solar cell matrix panel **500**, wherein one or more bypass diodes are connected in parallel to a preconfigured number of rows **315** of solar cells **320** and/or serial units **310**.

In such case of partial shading, sub cells **320s** stop to provide power that causes a decrease in the energy yield of entire panel **502**. In the example shown in Fig. 7b, the shaded area, that covers entire rows of sub cells **320**, prevents current from flowing through illuminated sub cells **320** in the respective strings of cells. In order to resolve such a problem, a quantity of "***f***" bypass diodes "***D***" are connected in parallel to a preconfigured number of rows **315** of sub cells of solar matrix array **400**, as shown in Fig. 6. ***f*** may be one bypass diode ***D***, or 3 bypass diodes ***D***, or 60 bypass diodes ***D***, or any other number of bypass diodes ***D***, connected to one or more rows **315** of matrix array **400**. The diodes ***D***

may be connected to one or more rows **315** of sub cells **320** or one or more rows **315** of serial unit **310**, see for example bypass diode D_1 and connected to row **315** of serial unit **310** that contains shaded rows of sub cells **320s** to thereby allow the string current to continue its flow.

Sub cells **320** of matrix solar array **400** may be arranged within a solar panel with or without bypass diodes ***D***, and may also be operatively coupled with a MPPT device in order to avoid a mismatch between panels **500** connected in strings of panels. Such a mismatch may occur when one or more panels **500** malfunction or are partially shaded, as described above (see example on Fig. 7b) or in preceding patents/patent applications of the present applicant.

Fig. 7c is a schematic illustration of an example of a solar panels array **507** (each panel in this example is, with no limitations, similar to solar cell matrix panel **500/502**), wherein panels **500** are connected in parallel, and wherein the solar array panel is coupled with a panel DC/AC inverter **950**, to invert the DC output voltage of the solar matrix array panel to AC voltage, for example to 220V or 110V, according to embodiments of the present invention.

To deal with the problem of loss of power as a result of a changing MPP, and to bring each solar-array module to work at or closely to its MPP, such as MPP-Tracer **552**, is used, as shown in Figs. 7d, 8a and others. Fig. 7d is a schematic illustration of an example of a solar panels array **509**, similar to the array of solar panels **507**, but array **509** is serially connected to the input of a battery charger **590**, typically having a maximum power point tracker (MPPT) optimizer **552**.

Reference is also made to Fig. 8a, illustrates an example solar matrix array panel **504** coupled with a power optimizer **550a** having a MPPT **552a**, to form a solar matrix array panel **504**. MPPT **552a** based optimizer **550a** is configured to provide maximum yield of power from the solar matrix array panel. The rows of sub cells of solar array matrix **400** of solar panel **504** are arranged without bypass diodes ***D*** and without a communication unit.

Fig. 8b illustrates an example solar matrix array panel **506** coupled with a power optimizer **550b** having a MPPT **552a** and a communication unit **554b**, to form a solar matrix array panel **506**. The rows of sub cells of solar array matrix **400** of solar panel **504** are arranged without bypass diodes ***D***.

Fig. 8c is a schematic illustration of an example solar matrix array panel **503** composed of a matrix solar array, such as matrix solar array **400**, that provides DC voltage and is serially connected to an inverter **950** that invert the DC voltage to AC voltage, for example, grid compatible electric power.

Fig. 8d is a schematic illustration of an example solar array system **511** composed of parallelly connected strings (**501**) of solar panels array, in this example, an array of solar panels **500**, connected in series, wherein the array of parallel connected strings of solar panels **501** provides DC voltage to an inverter **950** that invert the DC voltage to AC voltage.

Fig. 9 is a schematic illustration showing an example of a solar-array system module **600** including an electronic MPPT optimizer, an output voltage/current measurement unit **630** and a processor **620** for MPP regulation of a crisscross matrix of sub solar cells array $\mathbf{400_i}$, for example, with no limitations, being part of solar panel systems **504**, **506** and/or **508**. The resulting measurements are obtained from MPP based optimizer **652** by processor **620**, which may thereby change the output voltage of a solar array panel such as solar array panel **504/506/508**.

Fig. 10 is a schematic illustration showing an example of a solar-array system module **602** including a matrix array panel such as solar array panel **506/508** having, for example, crisscross matrix of sub solar cells $\mathbf{400_i}$, wherein solar array panel **506/508** is coupled to operate with a central monitoring and command/control sub system **700**.

Matrix array panel **506/508** further includes a MPPT optimizer **652**, an input/output voltage/current measurement unit **630** and a processor **620**. Solar-array system module **602** further includes a transmitter **640** that facilitate communication with central monitoring system sub **700**, that may intervene in the control of each individual solar-array module **602** and an entire system of solar panels array. Each individual solar-array module **602** further includes a transmitter **640** for transferring the measurement data obtained from output/input voltage/current meter **630** to a central controller/processor **710** of central controlling sub system **700**. Each individual solar-array module **602** further includes a receiver **642** for receiving control commands from central processor **710**.

Optionally, central controlling sub system **700** further provides information to a personal computer or a smart mobile device (**750**) regarding features, such as panel

energy, power, temperature and the like, of each panel or of the entire system **602** central controlling sub system **700** may be further configured to receive information from an operationally coupled remote computer or a remote smart mobile device (**750**), and for example, provides commands such as disable or enable a particular panel **506/508**, and the entire system (array) of panels.

Reference is also made to Fig. 11a, a schematic illustration showing an example solar-array system **800**, having several strings **840** of solar-array panels **504/506/508/509/513** (each may optionally be characterized as previously described), wherein strings **840** of solar-array panels **504/506/508/509/513** are interconnected in parallel. Each solar-array panel **504/506/508/509/513** may have a MPPT optimizer and monitoring and command/control sub-system. Each solar-array panel **504/506/508/509/513** includes an array of serial units **310** having "***n***" PV sub cells **320** interconnected in a crisscross configuration.

Fig. 11b, a schematic illustration showing an example solar-array system **801**, having several parallelly connected solar-array panels **504/506/508/509/513**, (each may optionally be characterized as previously described). Each solar-array panel **504/506/508/509/513** may have a MPPT optimizer and monitoring and command/control sub-system. Each solar-array panel **504/506/508/509/513** includes an array of serial units **310** having "***n***" PV sub cells **320** interconnected in a crisscross configuration.

It should be further noted that the regulation at the system level can still be performed by a DC/AC inverter (not shown) or by any of the aforementioned embodiments.

Reference is also made to Fig. 12a, a schematic illustration showing another example solar-array system **802**, having several strings **840** of solar-array panels **504/506/508/509/513** (each may optionally be characterized as previously described), wherein strings **840** of solar-array panels **504/506/508/509/513** are interconnected in parallel. Each solar-array panel **504/506/508/509/513** has a MPPT optimizer and monitoring and command/control communication sub-system. Each solar-array panel **504/506/508/509/513** includes an array of serial units **310** having multiple PV sub cells **320** interconnected in a crisscross configuration.

A central control sub system **700** having a central processor **710** received measurement data regarding voltage of each string **840** of solar-array panels

506/508/509/513, as well as voltage, current and output power of each solar-array panel **506/508/509/513**. After receiving the data from solar-array panels **506/508/509/513** through receiver **742**, central processor **710** sends the monitored data to customers PCs and Phones through transmitter **740**.

Central controlling sub system **700** may be further configured to receive information from an operationally coupled remote computer or a remote smart mobile device (**750**), for example commands such as able or disable a particular panel **506/508/509/513** or entire solar panel's array and/or other commands or information.

It should be note that central control sub system **700** may communicate with each solar-array module **506/508/509/513** through either wirelessly or wired communication means.

It should be further noted that the regulation at the system level can still be performed by a DC/AC inverter (not shown) or by any of the aforementioned embodiments.

Fig. 12b, a schematic illustration showing an example solar-array system **803**, having several parallelly connected solar-array panels **506/508/509/513**, (each may optionally be characterized as previously described). Each solar-array panel **506/508/509/513** may have a MPPT optimizer and monitoring and command/control sub-system. Each solar-array panel **506/508/509/513** includes an array of serial units **310** having "***n***" PV sub cells **320** interconnected in a crisscross configuration.

A central control sub system **700** having a central processor **710** received measurement data regarding voltage of each string **840** of solar-array panels **506/508/509/513**, as well as voltage, current and output power of each solar-array panel **506/508/509/513**. After receiving the data from solar-array panels **506/508/509/513**, through receiver **742** central processor **710** sends the monitored data to customer's PCs and Phones through transmitter **740.**

Central controlling sub system **700** may be further configured to receive information from an operationally coupled remote computer or a remote smart mobile device (**750**), for example commands such as able or disable a particular panel **506/508/509/513** or entire solar panel's array and/or other commands or information.

It should be noted that central control sub system **700** may communicate with each solar-array module **506/508/509/513** through either wirelessly or wired communication means.

It should be further noted that the regulation at the system level can still be performed by a DC/AC inverter (not shown) or by any of the aforementioned embodiments.

To deal with the problem of systems panels array loss of power as a result of a changing MPP due to changing conditions of irradiance level (that is, access of the solar cells to light) and/or temperature, a DC/AC inverter **950**, having a MPP-tracer, is used, as shown in Figs. 13a and 13b..

13a is a schematic illustration showing an example solar-array system **900**, having for example m * n solar-array panels **500/502/504/506/508**, each including a crisscross matrix of solar cells **310/320**, wherein the solar-array system **900** includes a common DC/AC inverter **950**. However, this solution works at a solar system level and not at a solar-array module level. Thus, this solution does not enable each solar-array module to operate at its MPP, which would provide greater efficiency over the entire system.

Fig. 13b is a schematic illustration showing an example solar-array system **902**, having for example parallelly connected solar-array panels **506/508/509/511**, each including a crisscross matrix of solar cells **310/320**. Each solar-array panel **506/508/509/511** is serially connected to a DC/AC inverter **950**, before being parallelly interconnected.

Fig. 13c is a schematic illustration of an example solar array system **904** having for example parallelly connected solar-array panels **506/508/509/511**, wherein each of the solar-array panels **506/508/509/511** provides DC voltage to a serially coupled inverter **950** that invert the DC voltage to AC voltage. The solar-array panels **506/508/509/511** are connected in parallel both before the DC voltage of each one is inverted to AC voltage, and after the DC voltage of each one is inverted to AC voltage.

Fig. 13d is a schematic illustration of an example solar array system **906** having, for example, parallelly connected solar-array panels **506/508/509/511**, wherein each of the solar-array panels **506/508/509/511** provides DC voltage to a serially coupled inverter **950** that invert the DC voltage to AC voltage. The solar-array panels **506/508/509/511** are connected in parallel both before the DC voltage of each one is inverted to AC voltage,

and after the DC voltage of each one is inverted to AC voltage. However, differing from solar array system **904**, each of the parallel connections of solar-array panels **506/508/509/511** that are connected in parallel both before the DC voltage of each one is inverted to AC voltage, is switchable by a switch **512**, typically, a controllable switch.

Other variations of the present invention are shown in Figs. 14-16. Fig. 14 is a schematic illustration of a solar cell module **305a**, wherein a DC to DC voltage converter **350**, that boost low panel voltage to desirable panel output voltage level or for MPP regulation, is connected to the output of solar cell matrix **300**, according to embodiments of the present invention; Fig. 15 is a schematic illustration of another solar cell module **305b**, wherein a number of DC to DC voltage converters **350**, that boosts low panel voltage to desirable panel output voltage level or for MPP regulation, is connected to the output of solar cell matrix **300**, according to other embodiments of the present invention. It should be noted that the DC to DC voltage converter **350** may be a Push-Pull converter, an UP converter, a forward converter, a maximum power point tracker (MPPT) device (**352**) or other types of converters, or a combination thereof.

The crisscross configuration of PV cells **310** minimizes the power losses of solar cell modules **305a/305b** (**305**), when any PV sub cell **320** malfunctions, whereas the current generated by sub cells connected in series to the malfunctioned sub cell are not lost but rerouted to bypass the malfunctioned sub cell. Using PV sub cells **320** rather than a regular PV cell **210**, substantially reduces the electrical current generated within solar cell module **305** and thereby, substantially reduces the losses of power due to conductive losses on solder points **212/312** between PV cells **320** (or **310**) and external conductors **204/304**; losses of power due to conductor connections between PV cells **320**, on busbars on solar cells, on conductors connecting PV cells to string of cells and conductors connecting string of PV cells to Junction Box

Hence, by decreasing the overall power losses of solar cell module **305**, the output power of solar cell module **305** is maximized.

Fig. 16a is another schematic example of a solar cell module **306**, wherein a number of DC to DC voltage converters **250/350** are connected to the output of the solar cell module **306**, according to some embodiments of the present invention. A multiplicity of other combinations of PV solar cells **210** and/or PV sub cells **310/320** may be

configured to a variety of other solar cell modules, all of which are within the scope of the present invention.

Fig. 17 is a schematic illustration of another example of a solar cell module **308**, wherein a number of DC to DC voltage converters **350** are connected to the output of the solar cell matrix, as shown in Fig. 4a, and number of MPPT devices **352** are connected to output of each one of above converters and the outputs of MPPT devices **352** are paralleled, according to some embodiments of the present invention.

The present invention being thus described in terms of several embodiments and examples, it will be appreciated that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are contemplated.

WHAT IS CLAIMED IS:

1. A solar power generation system (500, 504, 506, 507, 508, 509) for providing a predetermined operating power level and predetermined operating voltage level requirement, the system comprising at least one solar-array panel (500, 502), wherein each of said at least one solar-array panels (500, 502) comprises a multiplicity of PV solar sub cells (320),

wherein a preconfigured number of said PV solar sub cells (320) are electrically connected in series to form a serial-unit (310) or each individual serial unit (310) having just one PV solar sub cell (320), and wherein a preconfigured number of said serial units (310) are electrically connected in series to form a string of serial-units (330), said string of serial-units (330) is facilitated to produce a first output voltage level;

wherein a preconfigured number of said strings of serial-units (330), are electrically connected in parallel to form an array (300, 400) of said PV solar sub cells (320);

wherein in each of said strings of serial-units (330), each of said serial-units (310) is also connected in parallel to the neighboring serial-units of all other strings of serial-units (330), to form a crisscross matrix array (300, 400) of said serial units (310), said crisscross matrix array (300, 400) of said PV solar sub cells (320) is facilitated to produce a first output power level;

wherein said crisscross matrix array (300, 400) of said serial units (310) allows currents to bypass malfunctioning serial units (310), thereby improving the performance of the system; and

wherein each of said PV solar sub cell (320) is physically smaller than a regular PV solar cell (210), wherein a regular PV solar cell is a quadrangular of about 15cmX15cm, and wherein said PV solar sub cell (320) is a quadrangular PV solar cell (320) that is at least 50% smaller in area than a regular PV solar cell (210).

2. The solar power generation system as in claim 1, wherein each of said strings of serial-units (310) consists of the same number of said solar cells (320) electrically connected in series.

3. The solar power generation system (502) as in claim 1 further comprising a quantity of f bypass diodes (D) that are connected in parallel to a preconfigured number of rows (315) of said sub cells (320) of said matrix array (300, 400) of said solar-array panel (502).

4. The solar power generation system as in claim 1, wherein said sub cells are formed by cutting regular PV solar cell (210).

5. The solar power generation system (507) as in claim 1, wherein multiple said solar-array panels (500, 502) are connected in parallel and coupled to operate with a panel DC/AC inverter (950), to invert the DC output voltage of aid solar-array panels (500, 502) to AC voltage.

6. The solar power generation system (509) as in claim 5, wherein said array parallelly connected solar-array panels (500, 502, 507) are further connected in serial with a battery charger (590).

7. The solar power generation system (509) as in claim 6, wherein said battery charger (590) is coupled to operate with a maximum power point tracker (MPPT) optimizer (552), and wherein multiple said solar-array panels (500, 502 ,507) are connected in parallel.

8. The solar power generation system (511) as in claim 1, wherein multiple said solar-array panels (500, 502) are serially connected to form a string of solar-array panels (501), wherein said multiple strings of solar-array panels (501) are connected in parallel, and wherein said array of multiple strings of solar-array panels (501) are connected in parallel is further serially connected with a DC to AC inverter (950).

9. The solar power generation system (504) as in claim 1, wherein the DC output of said matrix array (300, 400) of said PV solar sub cells (320) is regulated by a MPPT optimizer (552), to provide maximum yield of power from said solar matrix array panel of the system.

10. The solar power generation system (506) as in claim 10 further comprising a communication unit (554b) facilitating communication between said MPPT optimizer and a remote computerized unit.

11. The solar power generation system (902) as in claim 10, wherein each of said string of solar-array panels (501) is serially connected with a DC to AC inverter (950), before being parallelly interconnected.

12. The solar power generation system (503) as in claim 10, wherein the DC output of said matrix array (300, 400) is serially connected to an inverter (950) that inverts the DC voltage to AC voltage.

13. The solar power generation system (600) as in claim 1 further comprising MPPT optimizer (652), an input/output voltage/current measurement unit (630) and a power-calculation-processor (620), wherein the maximum power point (MPP) of said crisscross matrix of sub solar cells (400_i) is regulated by said MPPT optimizer, based on the voltage/current measurements obtained by said measurement unit and analyzed by said power-calculation-processor.

14. The solar power generation system (602) as in claim 13 further comprising a central monitoring and control sub system (700) having a central processor (710), wherein said matrix array panel (506/508) further comprises a transmitter (640) and a receiver (642),
wherein said transmitter is configured to transferring the measurement data obtained from input /output voltage/current meter (630) to a central processor (710);
wherein said receiver is configured to receive commands from said central processor (710); and
wherein said power-calculation-processor (620) is configured to provide said MPPT optimizer with regulation data to thereby regulate said MPP of said crisscross matrix of sub solar cells (400_i).

15. The solar power generation system as in claim 14, wherein said central processor (710) is further configured to send and/or receive data to and/or from a remote processor (750).

16. The solar power generation system as in claim 15, wherein said remote processor is selected from a group including a remote computer and a smart mobile device.

17. The solar power generation system as in claim 15, wherein said data is selected from a group including panel energy, power, temperature, voltage, current, time and date a disable command and an enable command.

18. The solar power generation system (800) as in claim 10, wherein multiple said solar-array panels (504, 506, 508, 509, 511), that are MPP regulated, are serially connected to form a string

of solar-array panels (840), and wherein said multiple strings of solar-array panels (840) are connected in parallel.

19. The solar power generation system (801) as in claim 10, wherein multiple said solar-array panels (504, 506, 508, 509, 511), that are MPP regulated, are connected in parallel.

20. The solar power generation system (902) as in claim 19, wherein each of said solar-array panels (504, 506, 508, 509, 511) is serially connected with a DC to AC inverter (950), before being interconnected in parallel.

21. The solar power generation system (904) as in claim 20, wherein each of said solar-array panels (504, 506, 508, 509, 511) is serially connected with a DC to AC inverter (950), and wherein said solar-array panels (504, 506, 508, 509, 511) are connected in parallel before being serially connected with said DC to AC inverter (950) and after being serially connected with said DC to AC inverter (950).

22. The solar power generation system (906) as in claim 21, wherein said parallel connection of said solar-array panels (504, 506, 508, 509, 511) before being serially connected with said DC to AC inverter (950) is switchable.

23. The solar power generation system (802) as in claims 18 and 19 further comprising a central monitoring and control sub system (700) having a central processor (710), wherein each of said matrix array panel (506, 508, 509, 511) further comprises a processor (620), output/input voltage/current measurement (630), transmitter (640) and a receiver (642),
wherein said transmitter is configured to transferring the measurement data obtained from input/output voltage/current meter (630) to a central processor (710);
wherein said receiver is configured to receive commands from said central processor (710); and
wherein said power-calculation-processor (620) is configured to provide said MPPT optimizer with regulation data to thereby regulate said MPP of said crisscross matrix of sub solar cells of said matrix array panels (506, 508, 509, 511).

24. The solar power generation system (305a) as in claim 1, wherein the DC output of said matrix array (300, 400) is connected to a DC/DC power converter (350).

25. The solar power generation system (305b) as in claim 1, wherein the DC output of said matrix array (300, 400) is connected to multiple DC/DC power converters (350).

26. The solar power generation system (306) as in claim 1, wherein the DC output of each of said strings of serial-units (330) of said matrix array (300, 400) is serially connected to a DC/DC power converter (350), and wherein said parallelly connected DC/DC power converters (350) are serially connected to a MPPT (352, 552a).

27. The solar power generation system (306) as in claim 1, wherein the DC output of each of said strings of serial-units (330) of said matrix array (300, 400) is serially connected to a DC/DC power converter (350), and wherein each said DC/DC power converters (350) is serially connected to a respective MPPT (352, 552a).

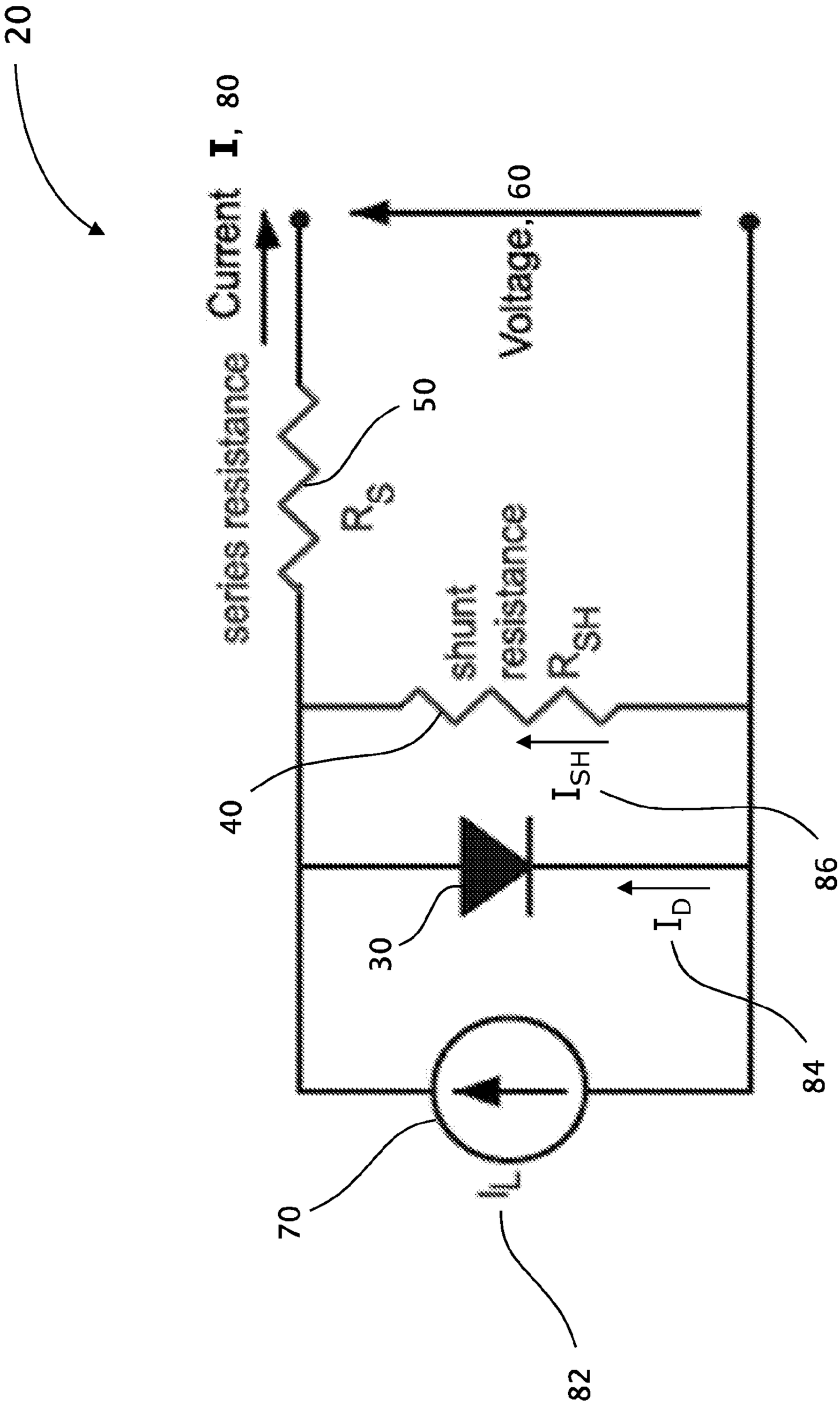


Fig 1
PRIOR ART

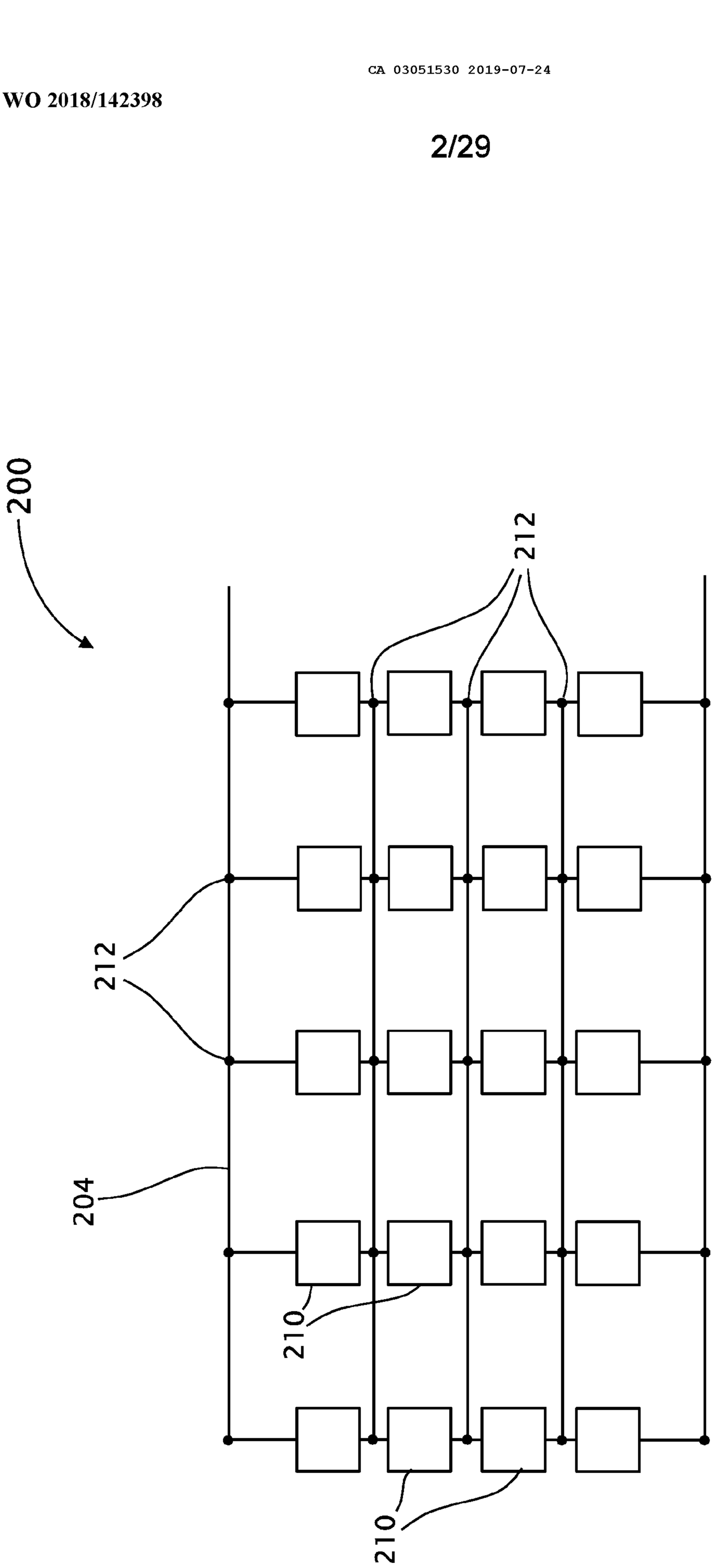


Fig 2
PRIOR ART

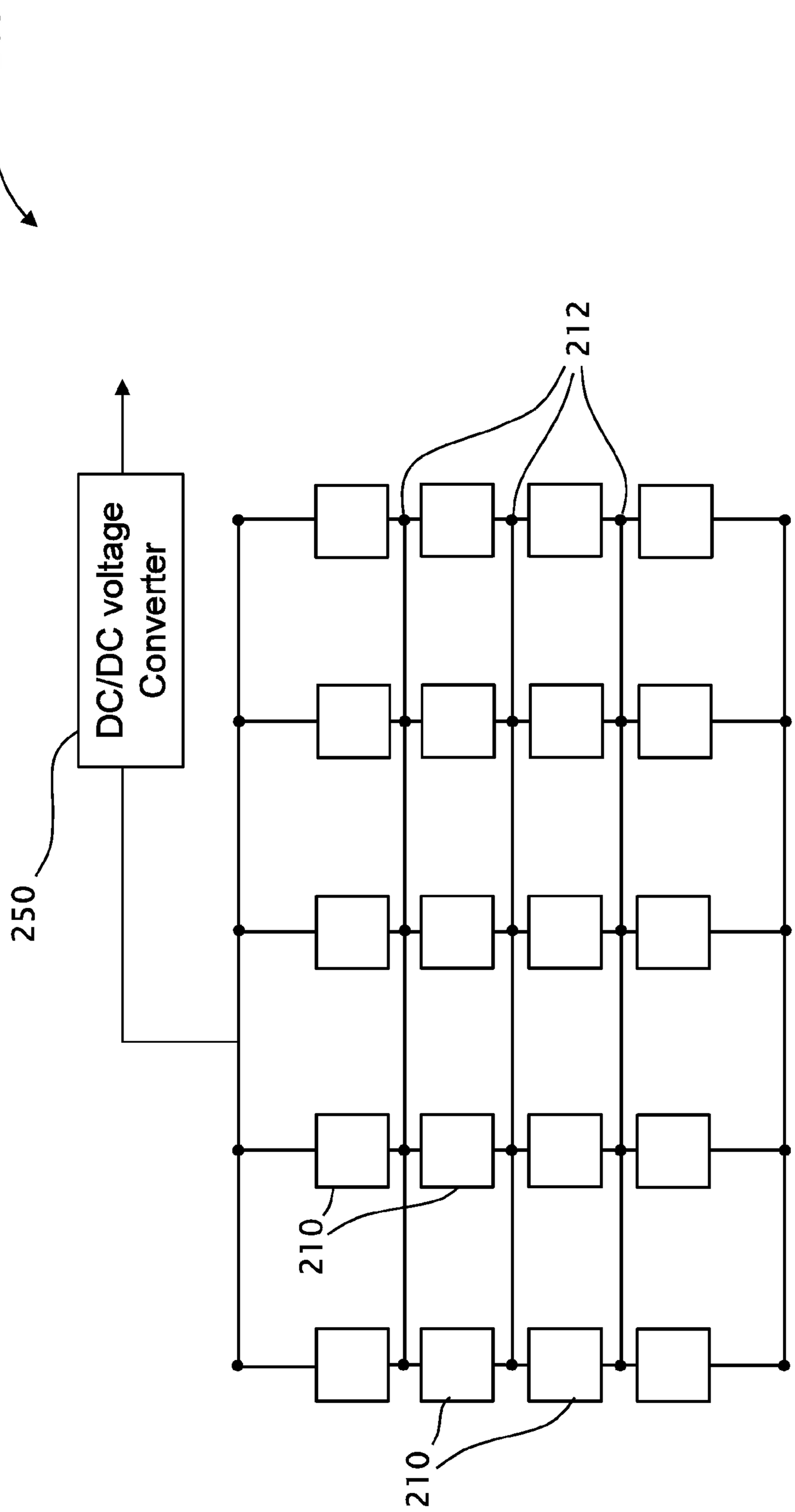


Fig 3
PRIOR ART

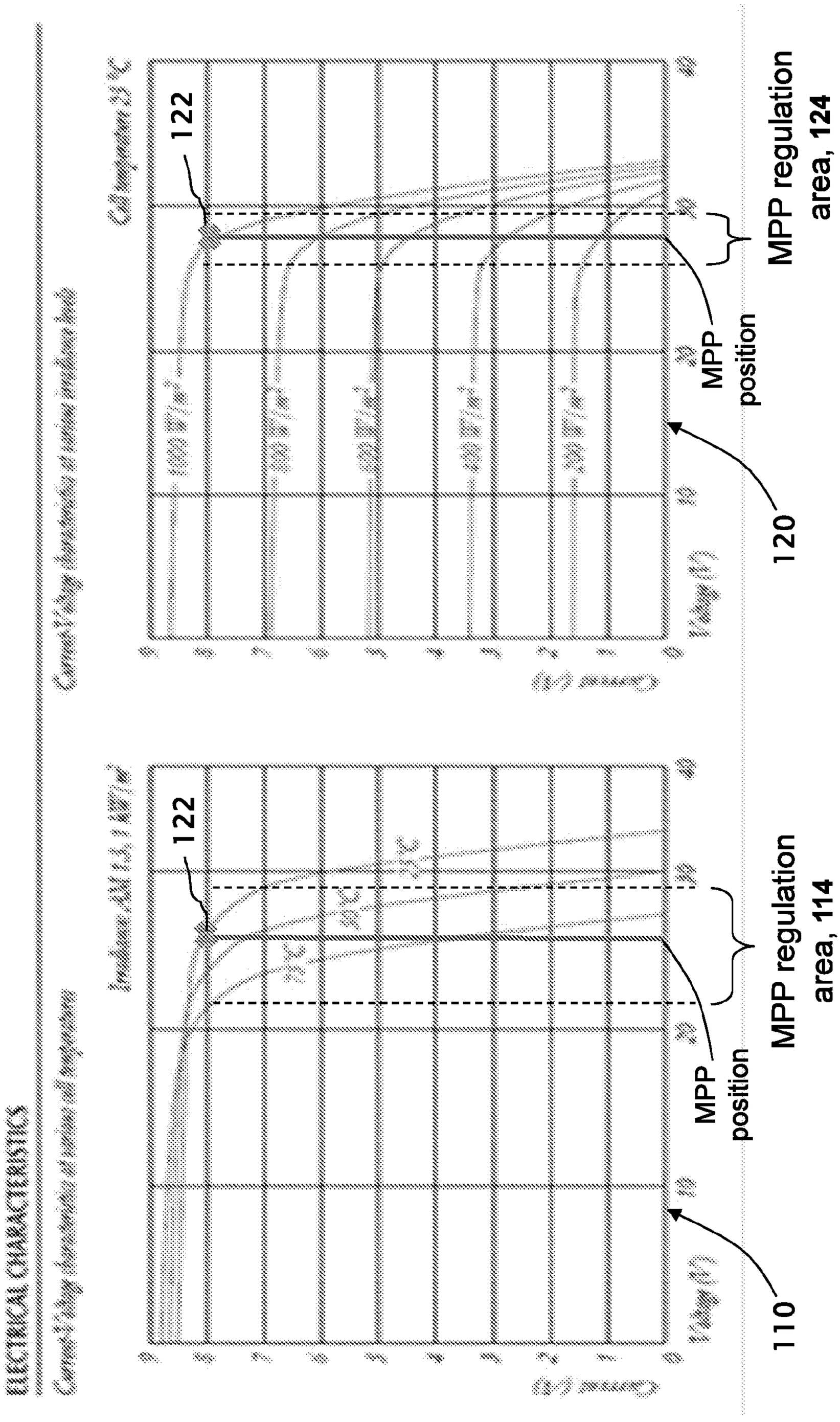

MPP
ELECTRICAL CHARACTERISTICS
Current-voltage characteristics at various irradiation levels
Current (A)
Voltage (V)
122
MPP position
MPP regulation area, 114
110
Current-voltage characteristics at various irradiation levels
Current (A)
Voltage (V)
122
MPP position
MPP regulation area, 124
120

Fig 4

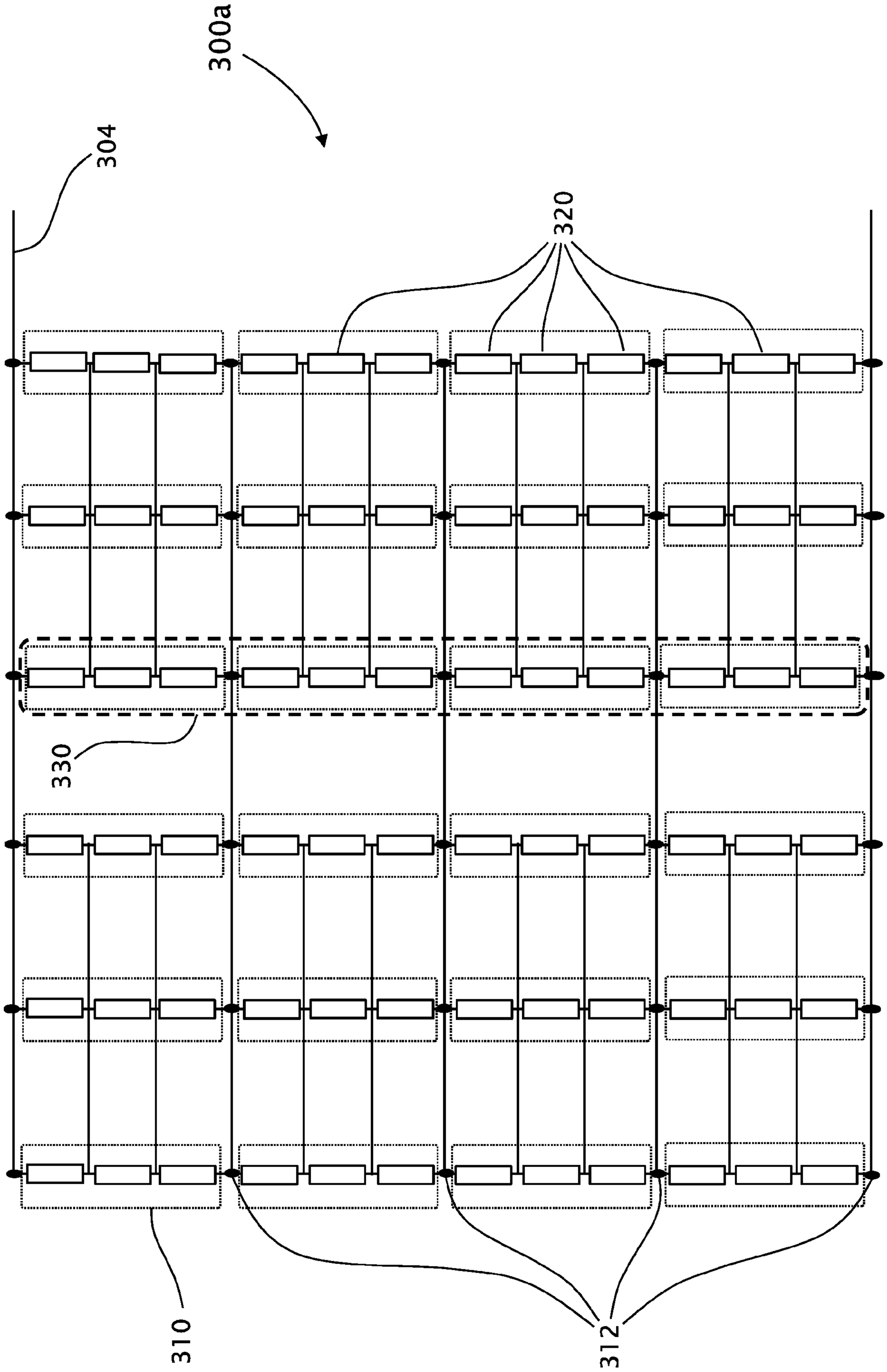


Fig. 5a

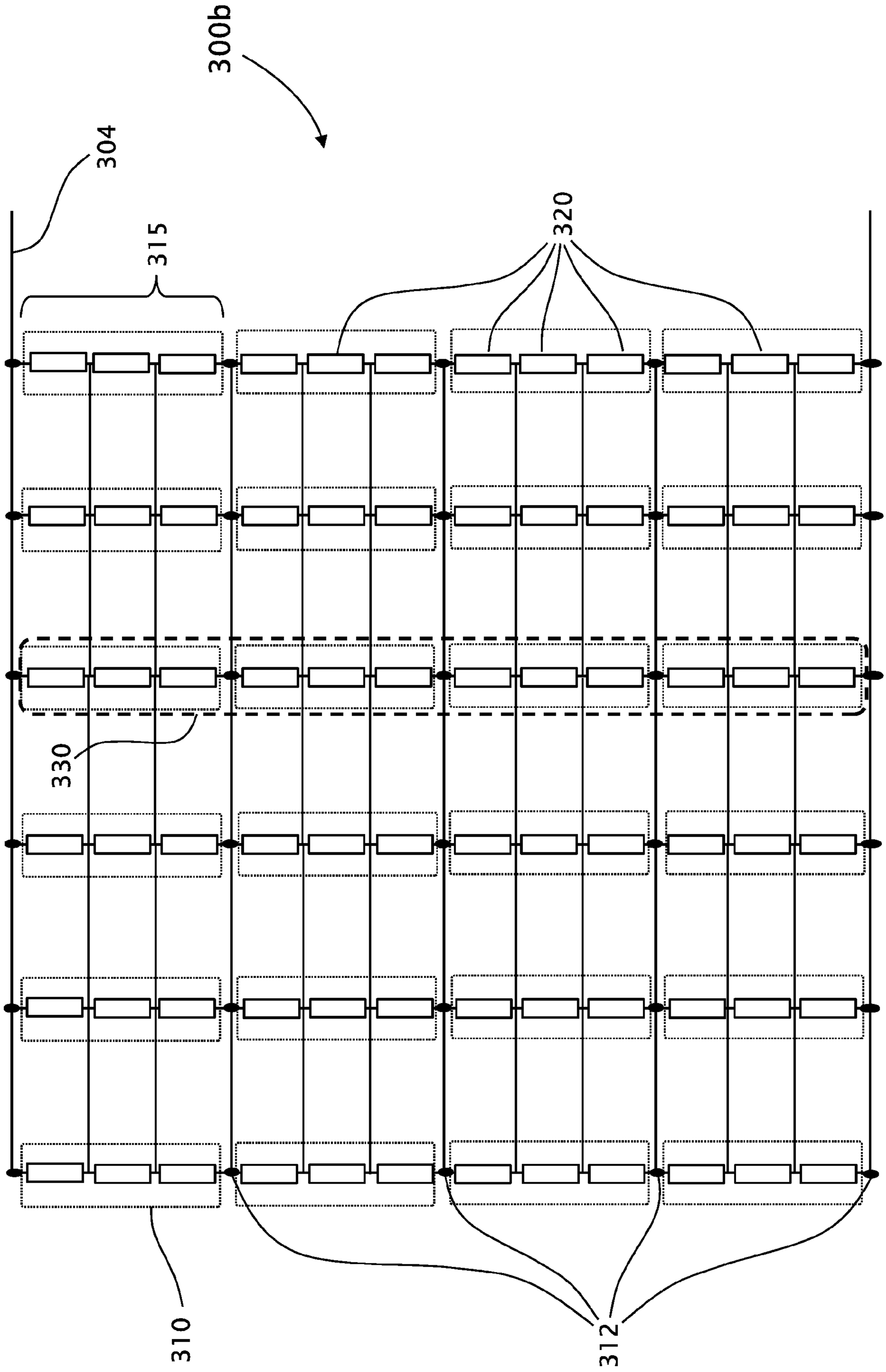


Fig. 5b

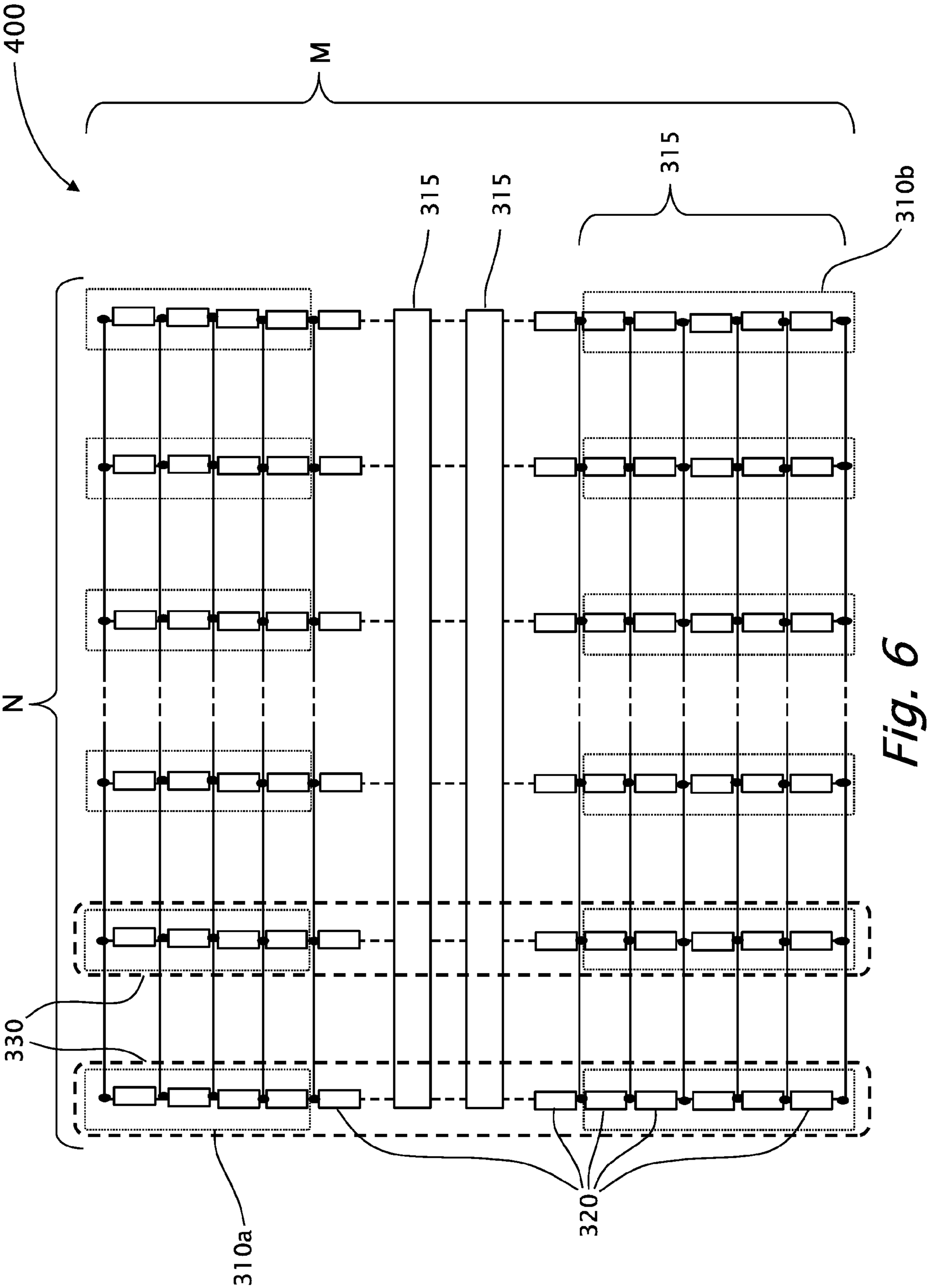


Fig. 6

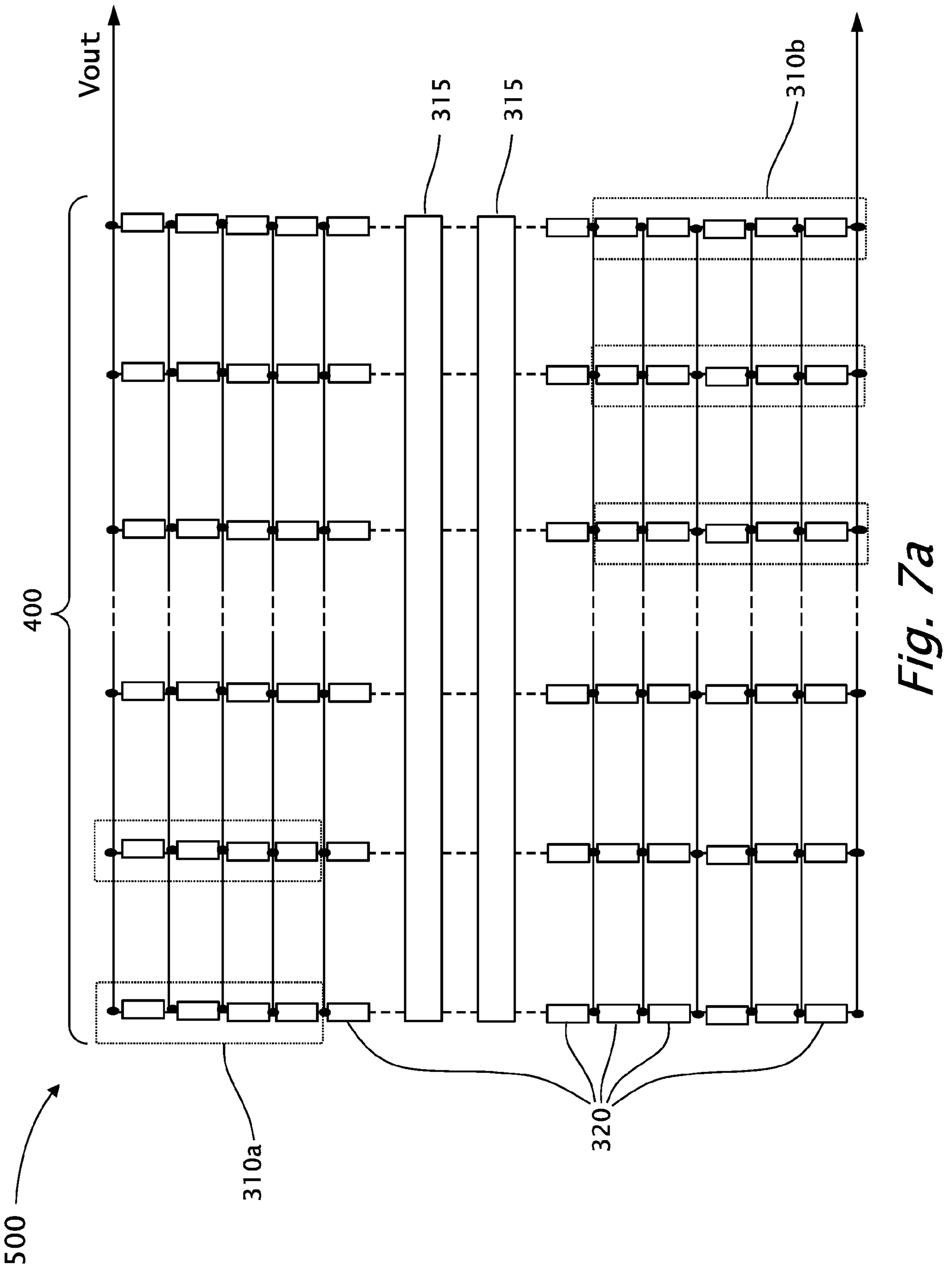


Fig. 7a

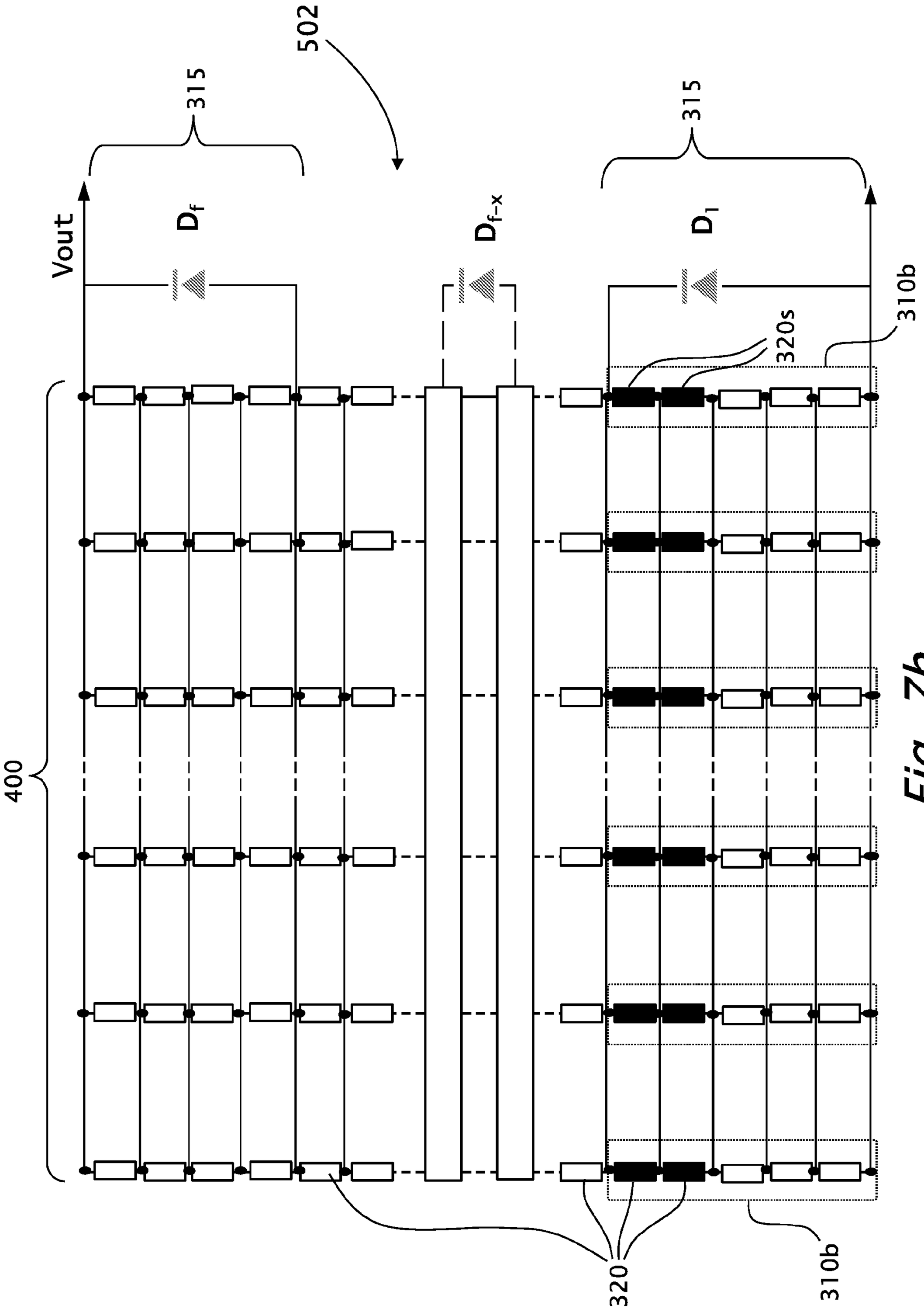


Fig. 7b

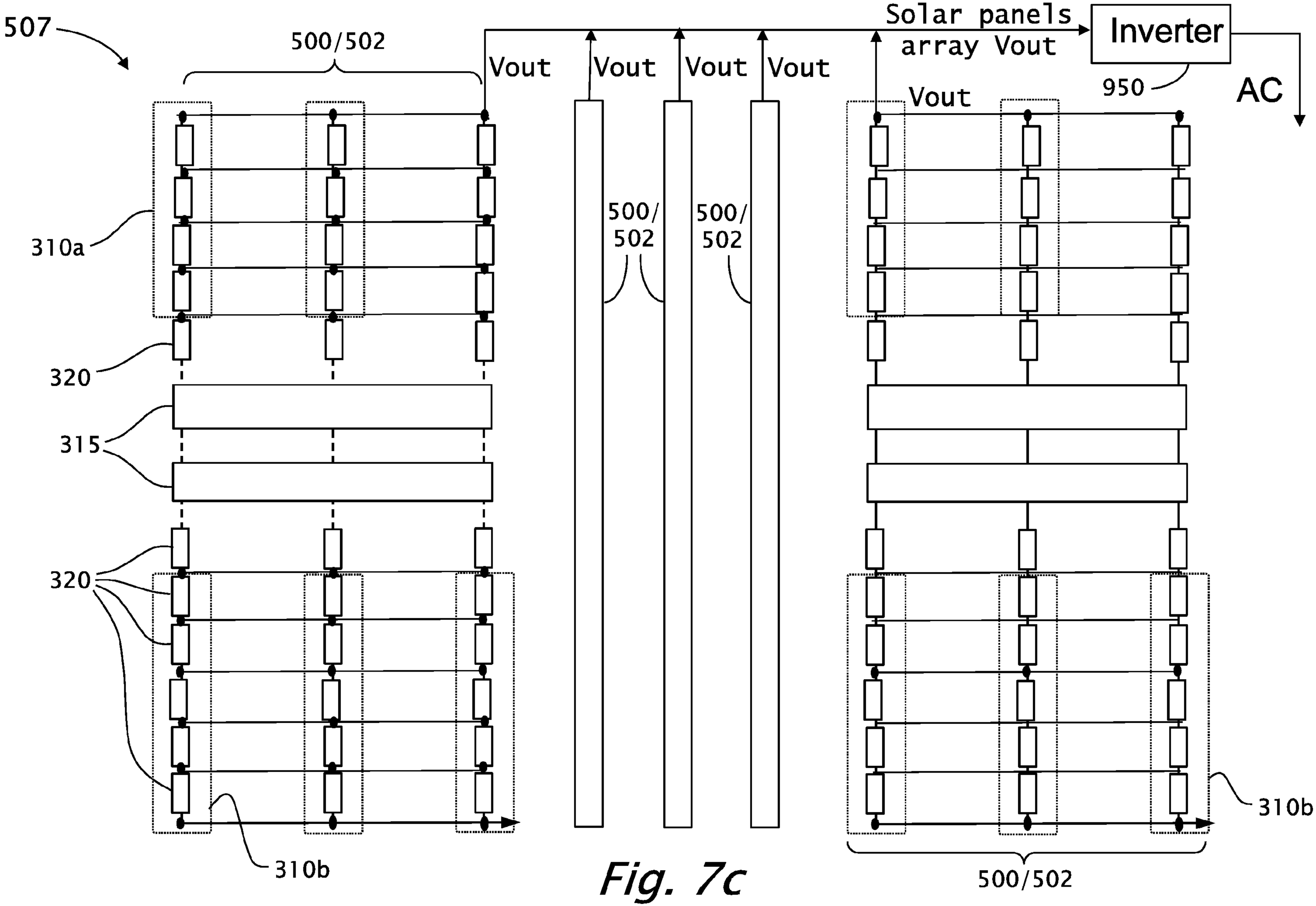

507
500/502
Vout
Vout
Vout
Vout
Solar panels array Vout
Inverter
950
AC
Vout
310a
320
315
320
500/502
500/502
310b
500/502
310b

Fig. 7c

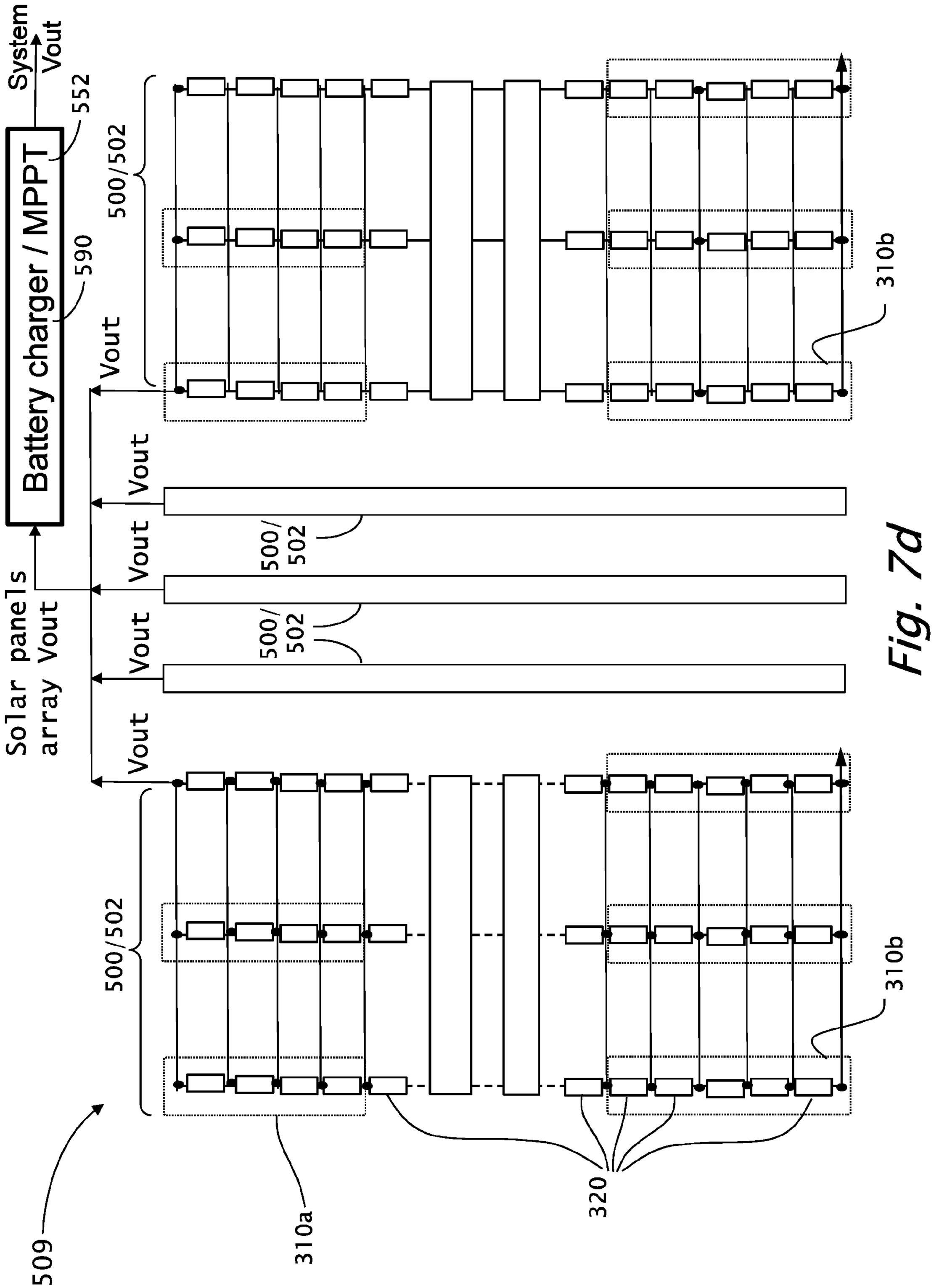

Solar panels array Vout
Battery charger / MPPT
552
590
System Vout
500/502
Vout
310b
320
310a
509

Fig. 7d

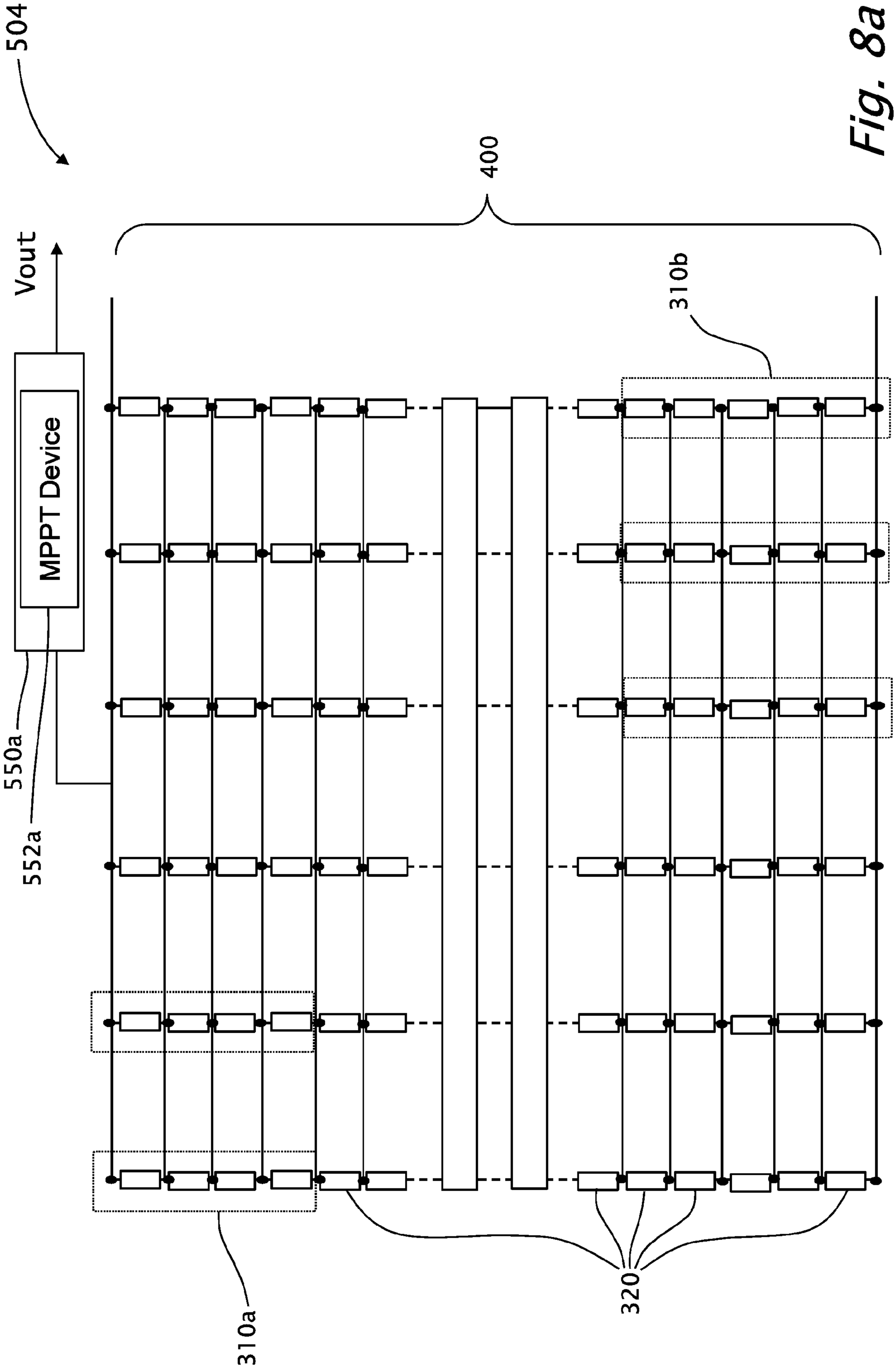


Fig. 8a

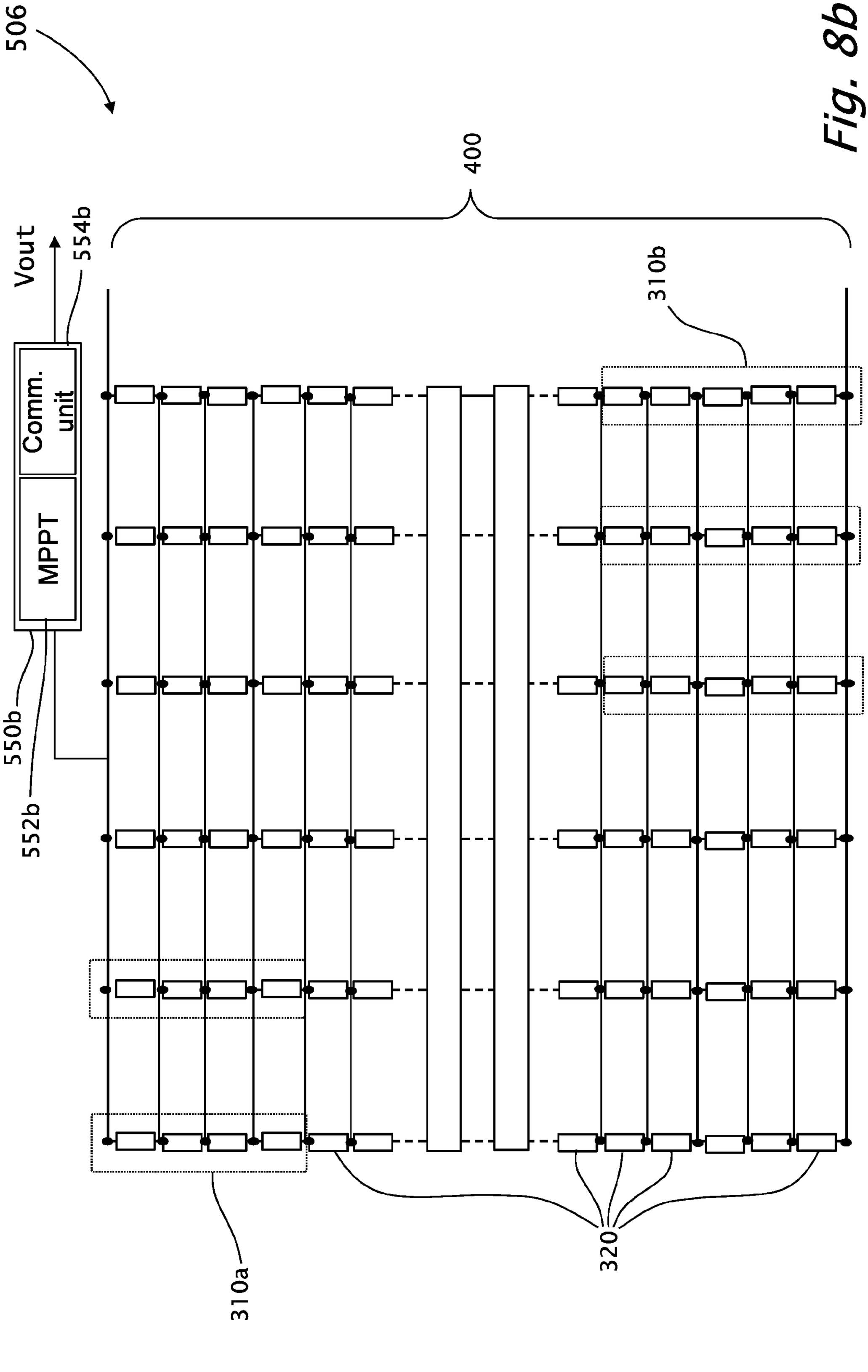


Fig. 8b

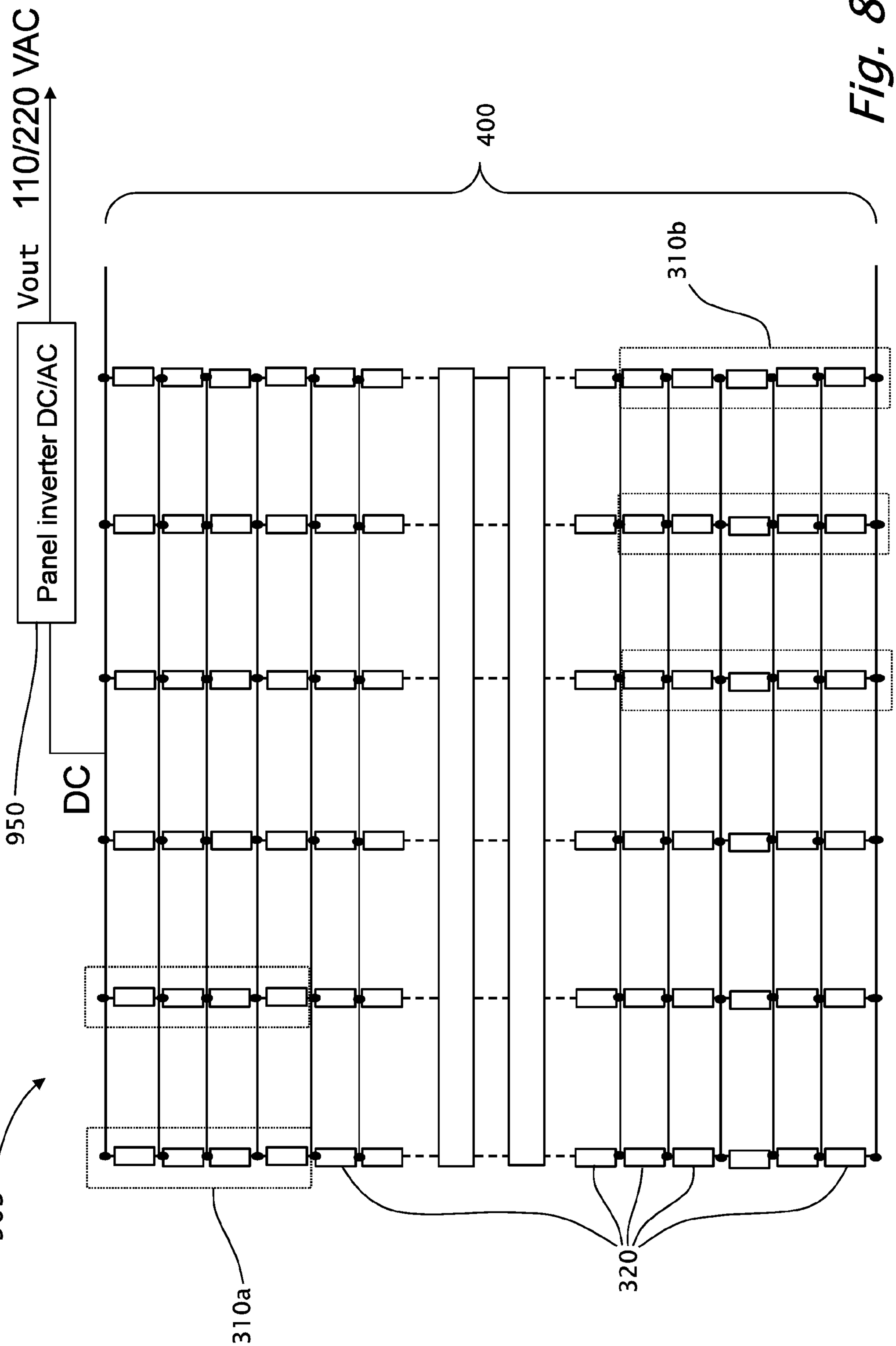

110/220 VAC
Vout
Panel inverter DC/AC
DC
950
503
400
310b
310a
320

Fig. 8c

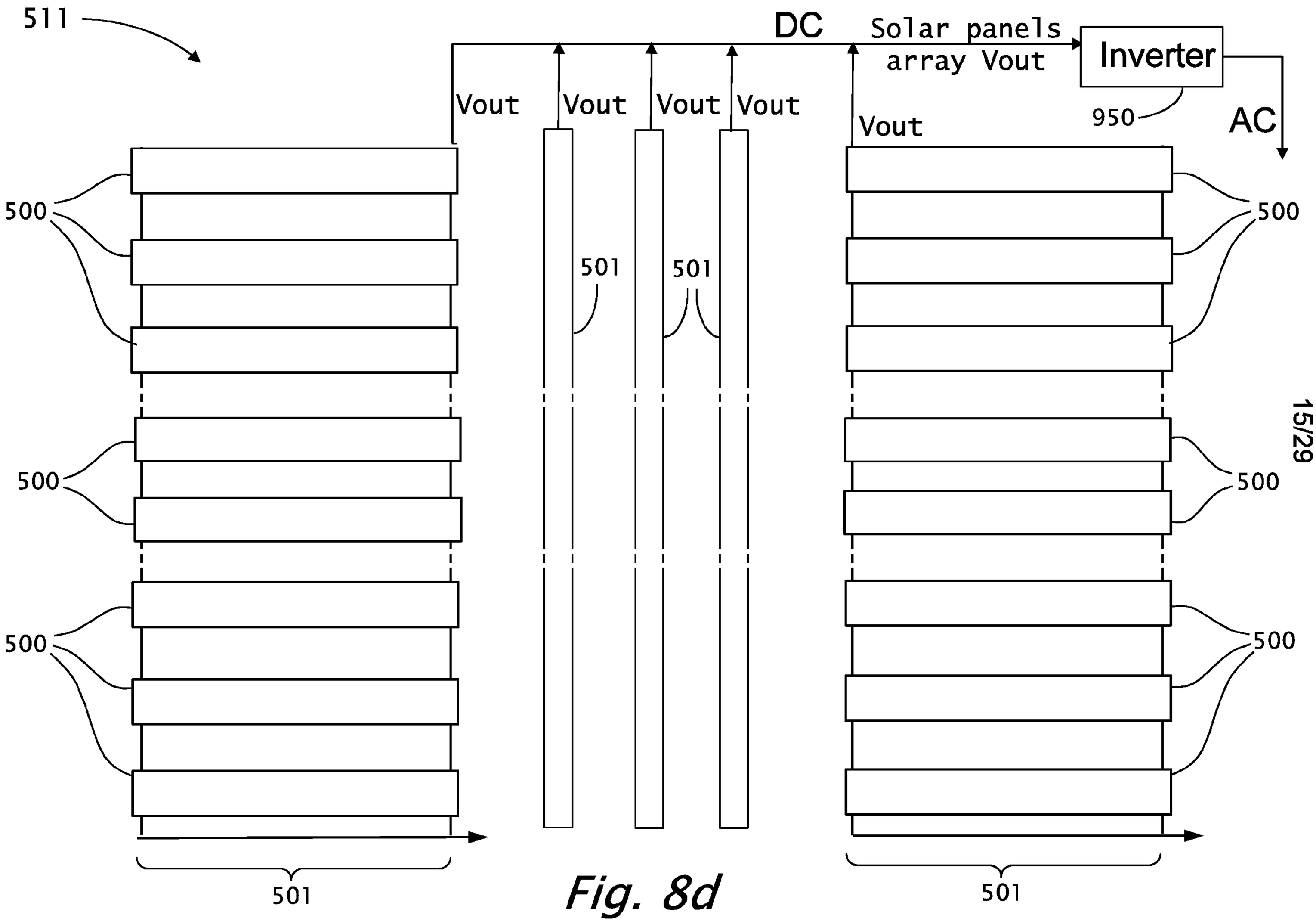

511
DC
Solar panels
array Vout
Inverter
950
AC
Vout
Vout
Vout
Vout
Vout
500
500
501
501
500
500
500
500
501
501

Fig. 8d

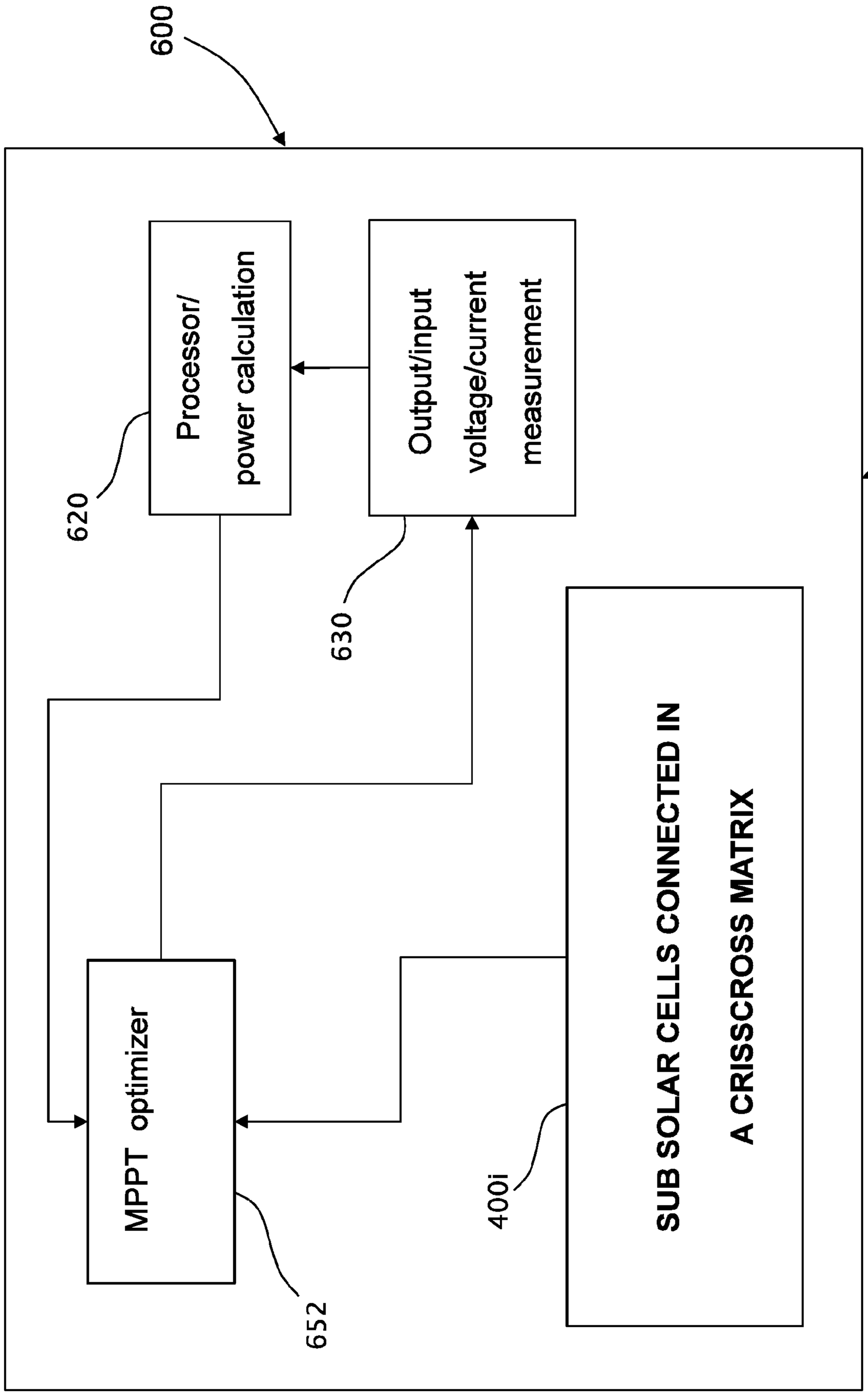

600
Processor/
power calculation
620
Output/input
voltage/current
measurement
630
504/
506/
508
MPPT optimizer
652
400i
SUB SYSTEM OF 3 SOLAR CELLS CONNECTED IN
A CRISSCROSS MATRIX

Fig. 9

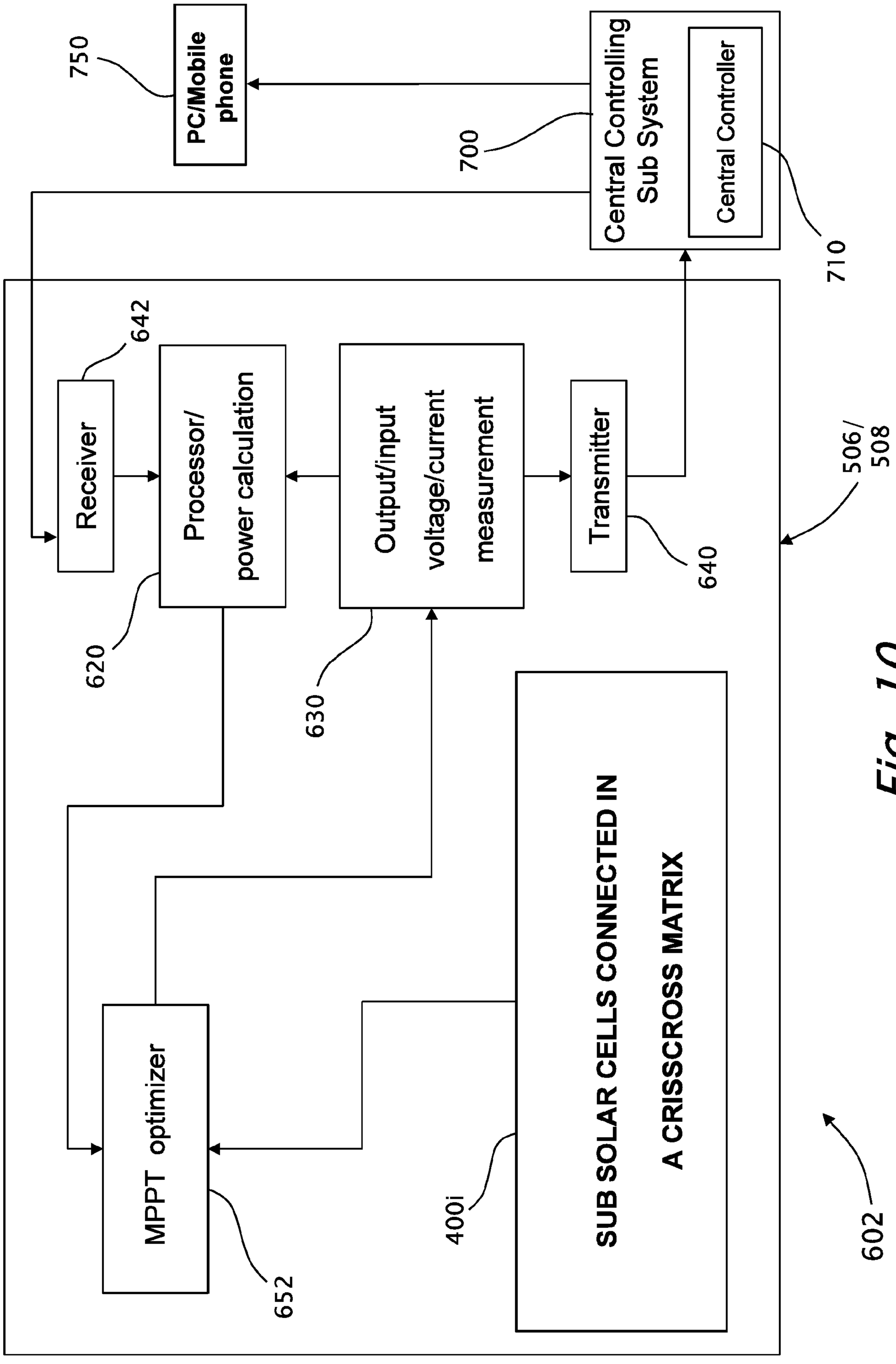

750
PC/Mobile phone
700
Central Controlling Sub System
Central Controller
710
642
Receiver
Processor/ power calculation
Output/input voltage/current measurement
Transmitter
506/ 508
640
620
630
MPPT optimizer
652
400i
SUB SOLAR CELLS CONNECTED IN A CRISSCROSS MATRIX
602

Fig. 10

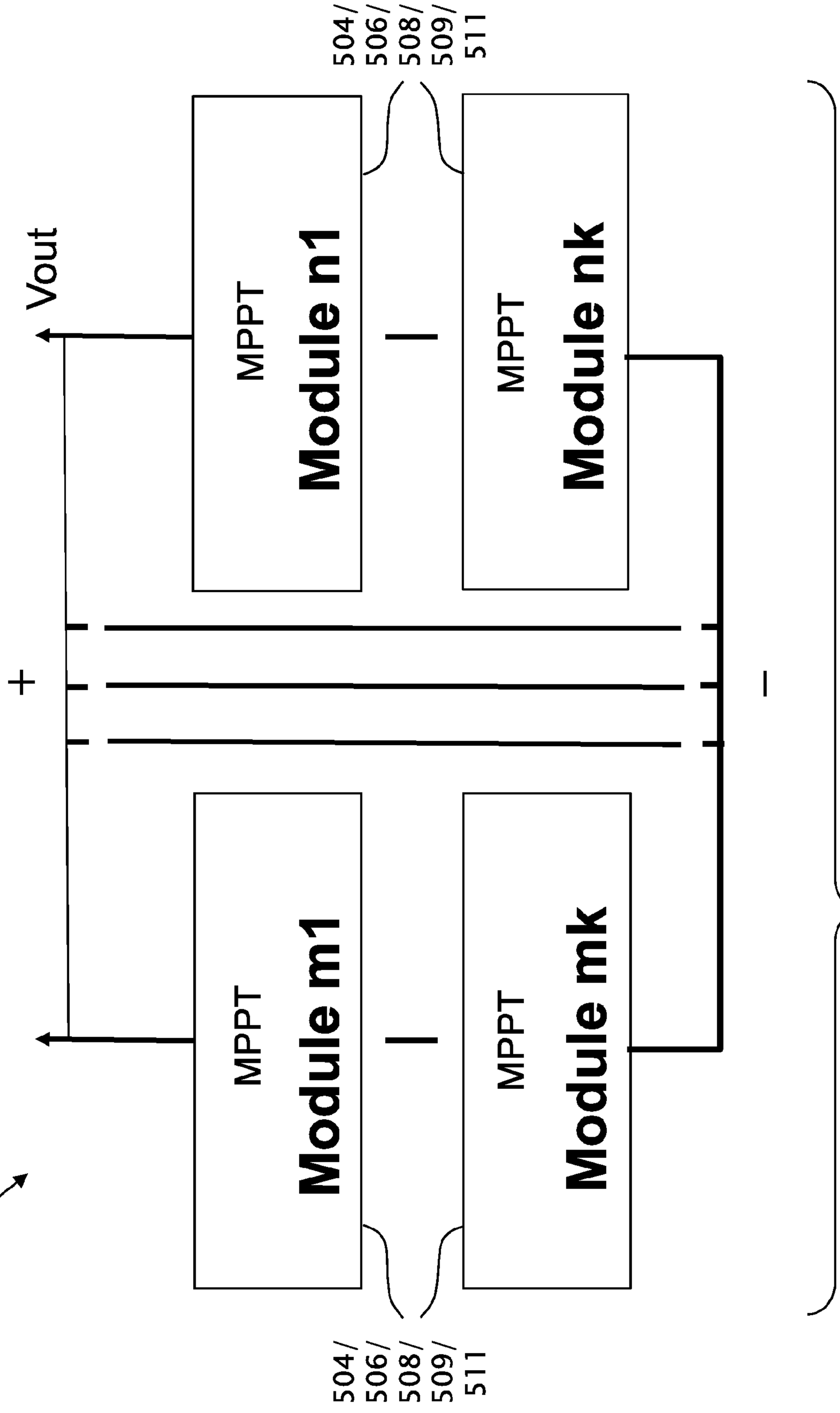

504/
506/
508/
509/
511
Vout
MPPT
Module n1
MPPT
Module nk
+
–
MPPT
Module m1
MPPT
Module mk
840
800
504/
506/
508/
509/
511

Fig. 11a

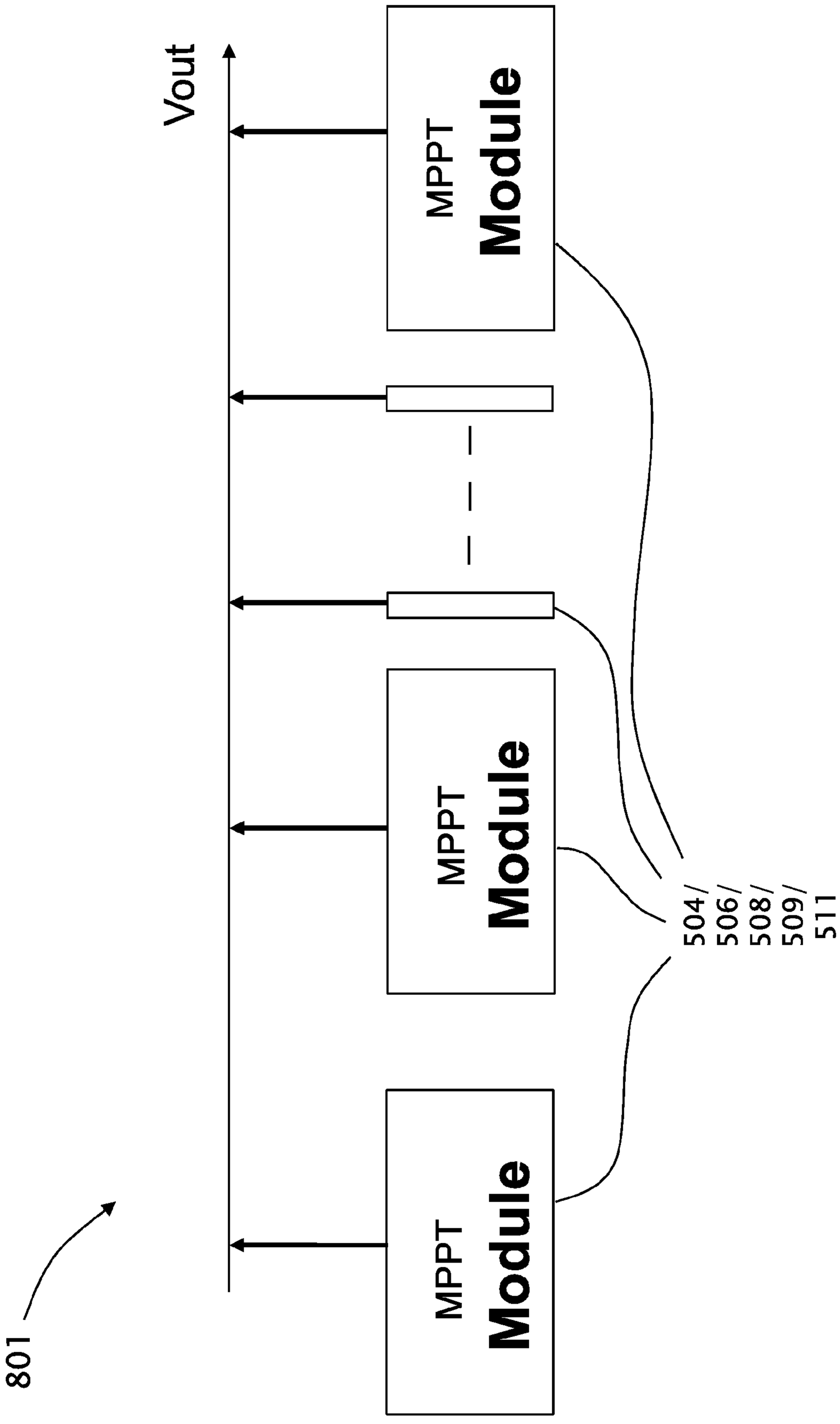

Vout
MPPT
Module
MPPT
Module
MPPT
Module
MPPT
Module
504/
506/
508/
509/
511
801

Fig. 11b

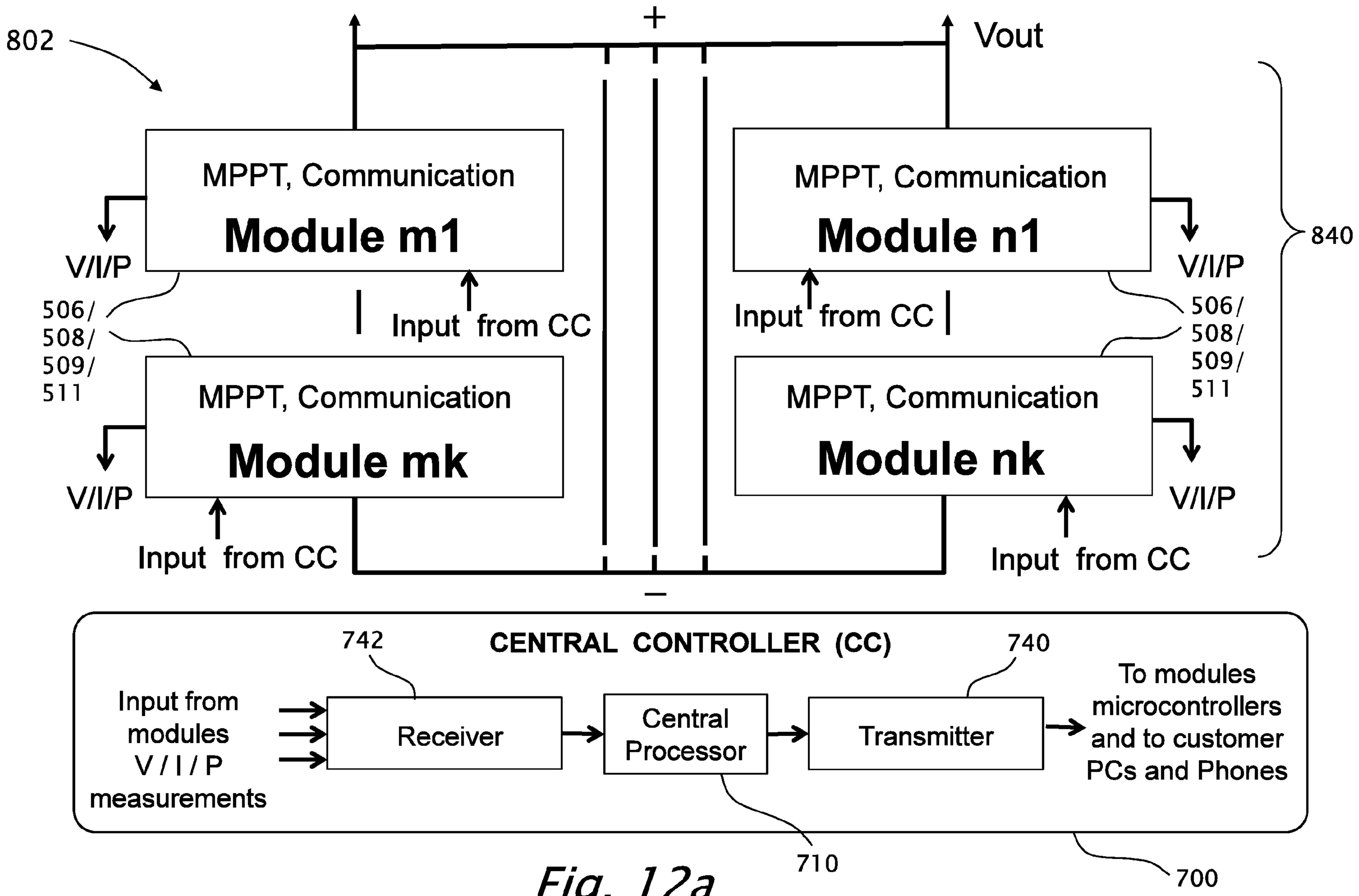

802
+
Vout
MPPT, Communication
Module m1
MPPT, Communication
Module n1
V/I/P
506/
508/
509/
511
Input from CC
MPPT, Communication
Module mk
MPPT, Communication
Module nk
840
–
742
CENTRAL CONTROLLER (CC)
740
Input from modules V / I / P measurements
Receiver
Central Processor
Transmitter
To modules microcontrollers and to customer PCs and Phones
710
700

Fig. 12a

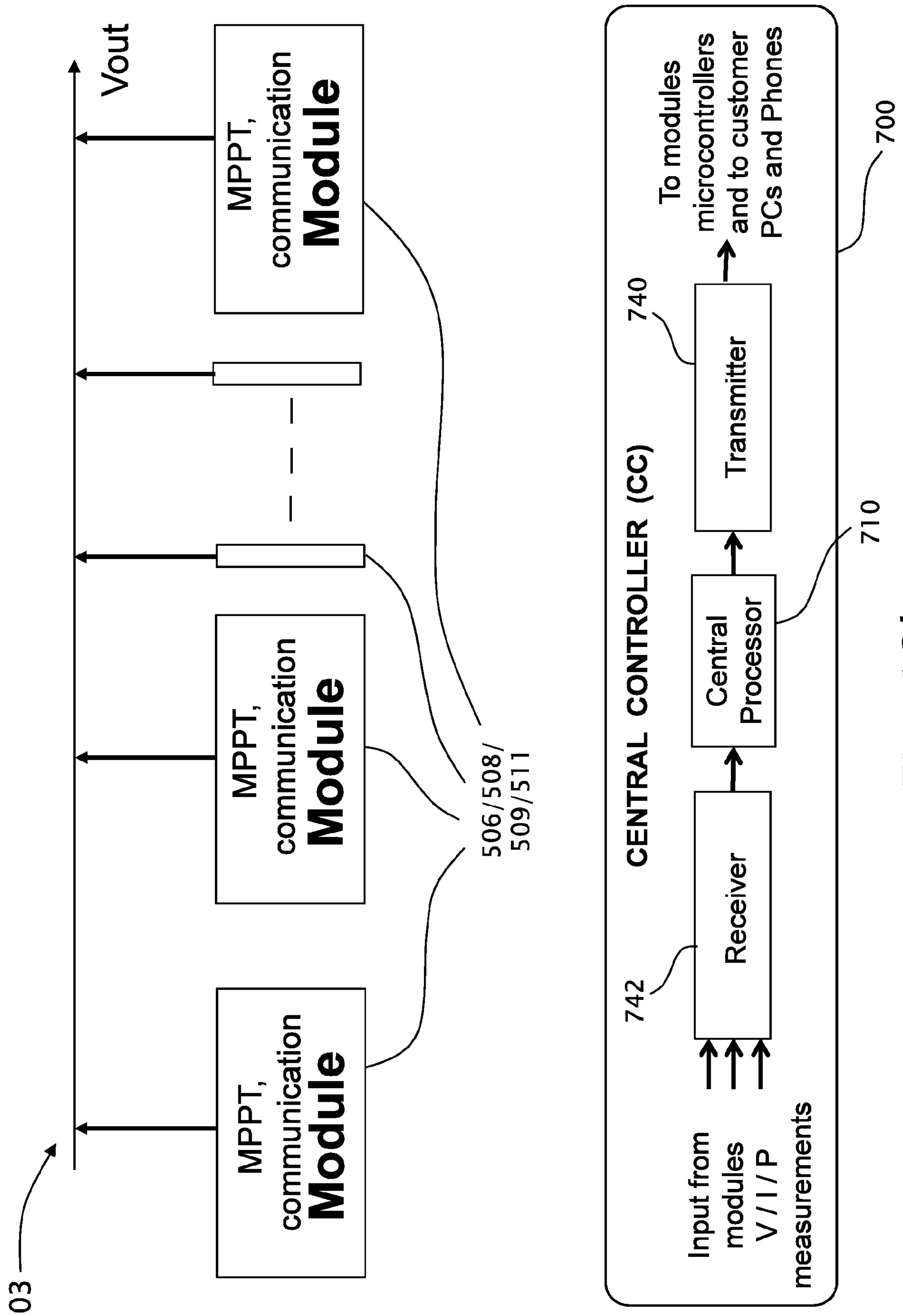

Vout
MPPT, communication Module
506/508/ 509/511
803
700
To modules microcontrollers and to customer PCs and Phones
CENTRAL CONTROLLER (CC)
740
Transmitter
710
Central Processor
Receiver
742
Input from modules V / I / P measurements

Fig. 12b

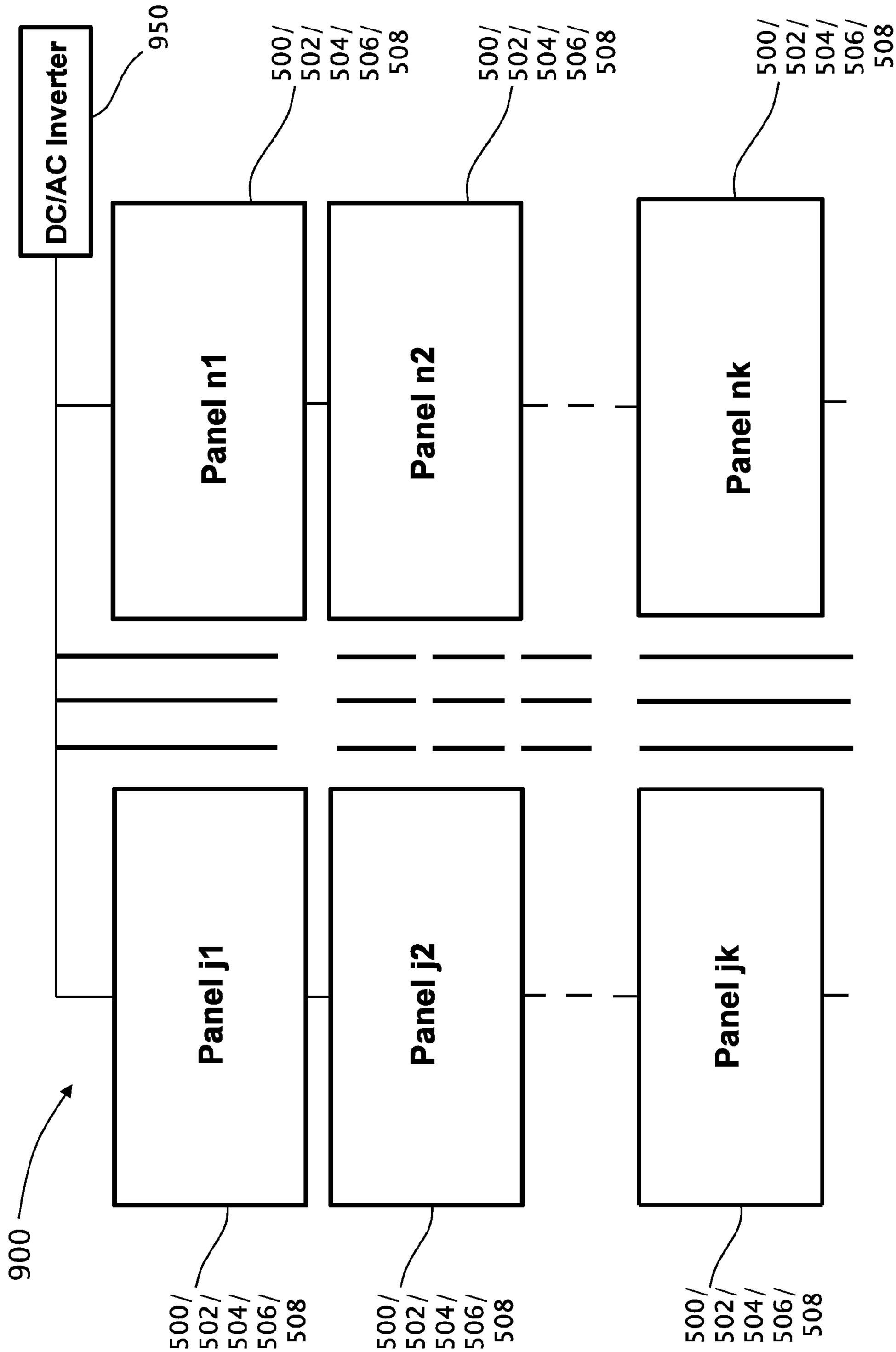

900
DC/AC Inverter
950
Panel n1
Panel n2
Panel nk
Panel j1
Panel j2
Panel jk
500/ 502/ 504/ 506/ 508

Fig. 13a

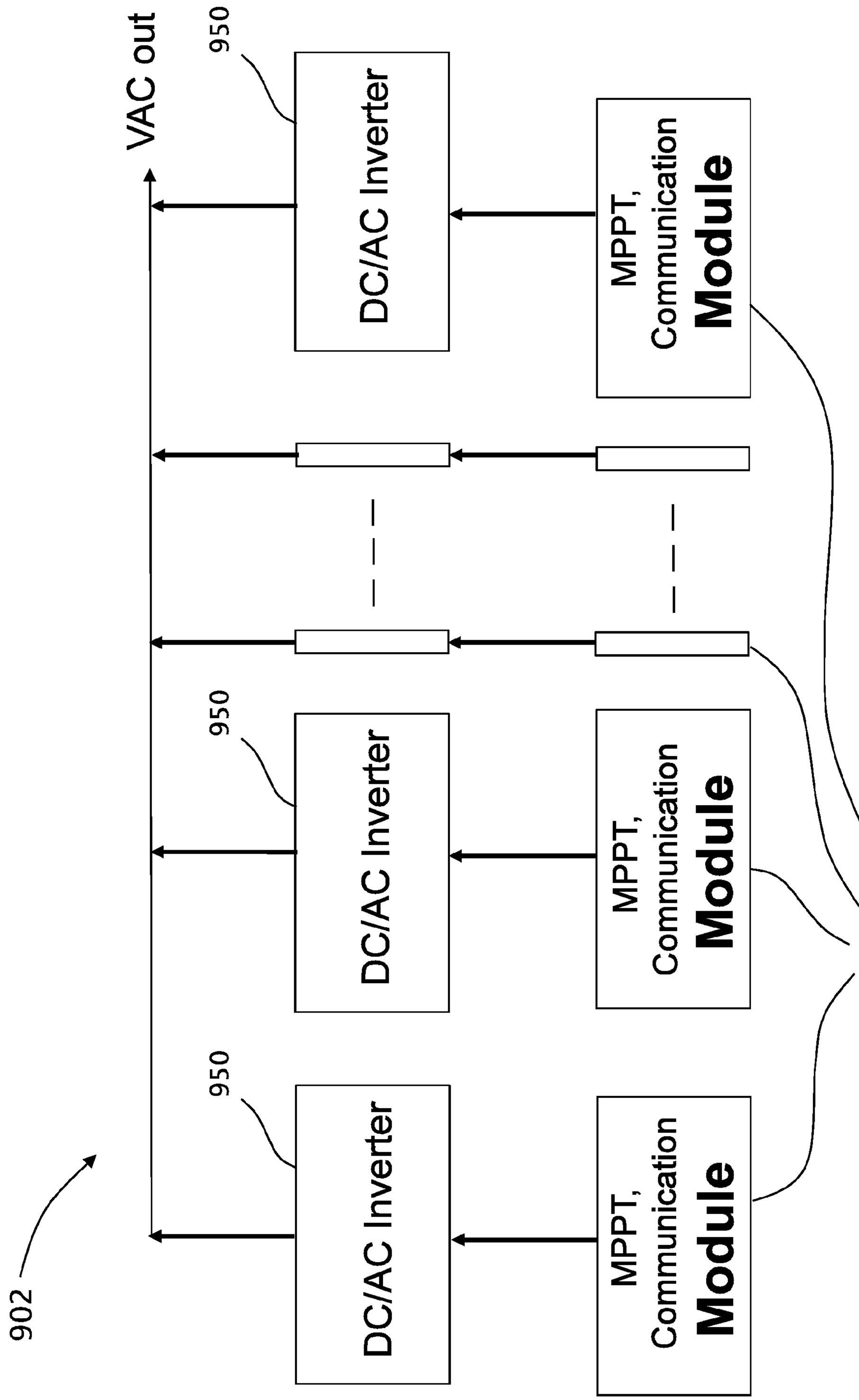

902
950
DC/AC Inverter
MPPT,
Communication
Module
506/508/
509/511

Fig. 13b

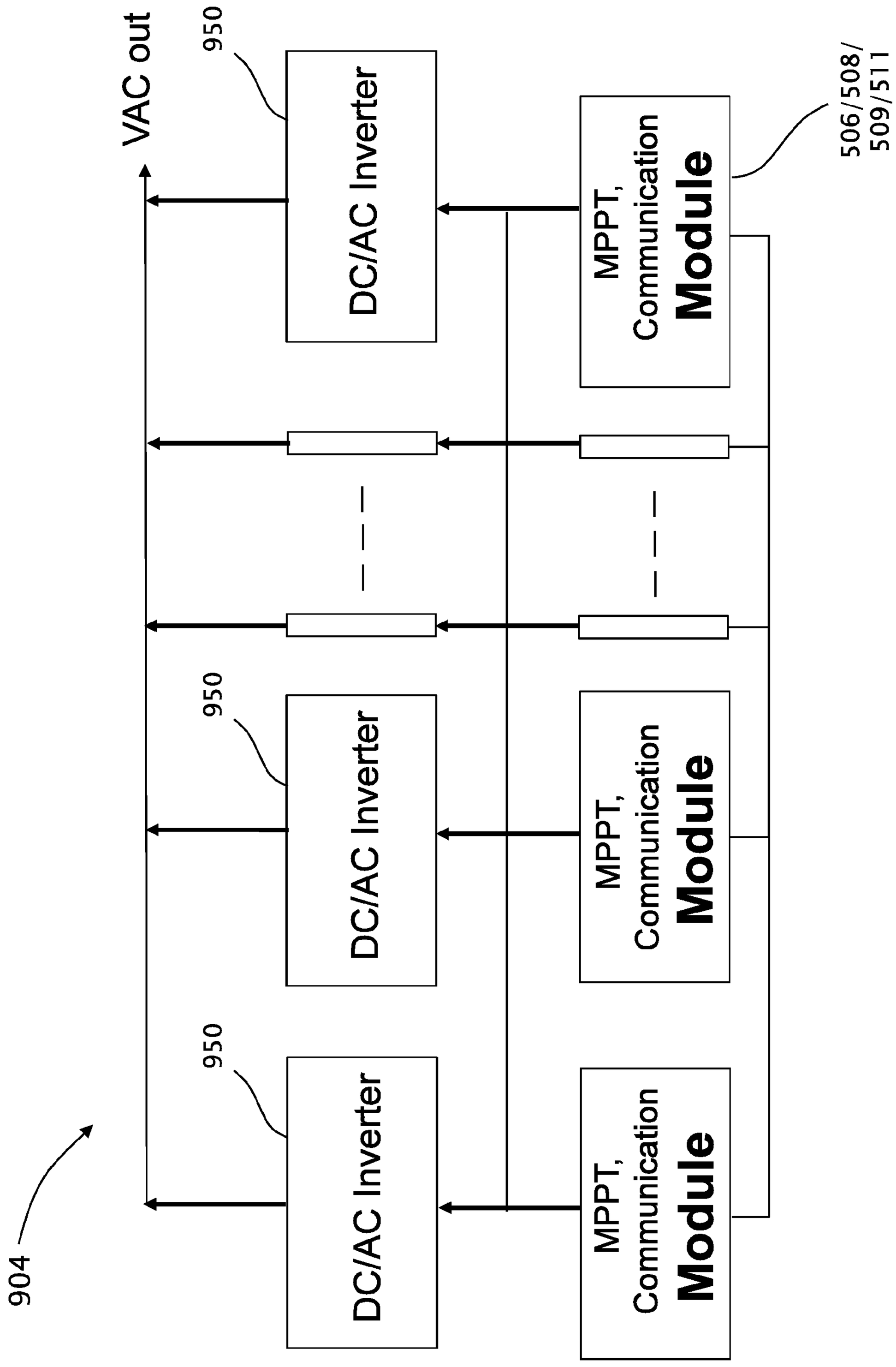

904
950
DC/AC Inverter
MPPT, Communication Module
506/508/509/511
VAC out

Fig. 13c

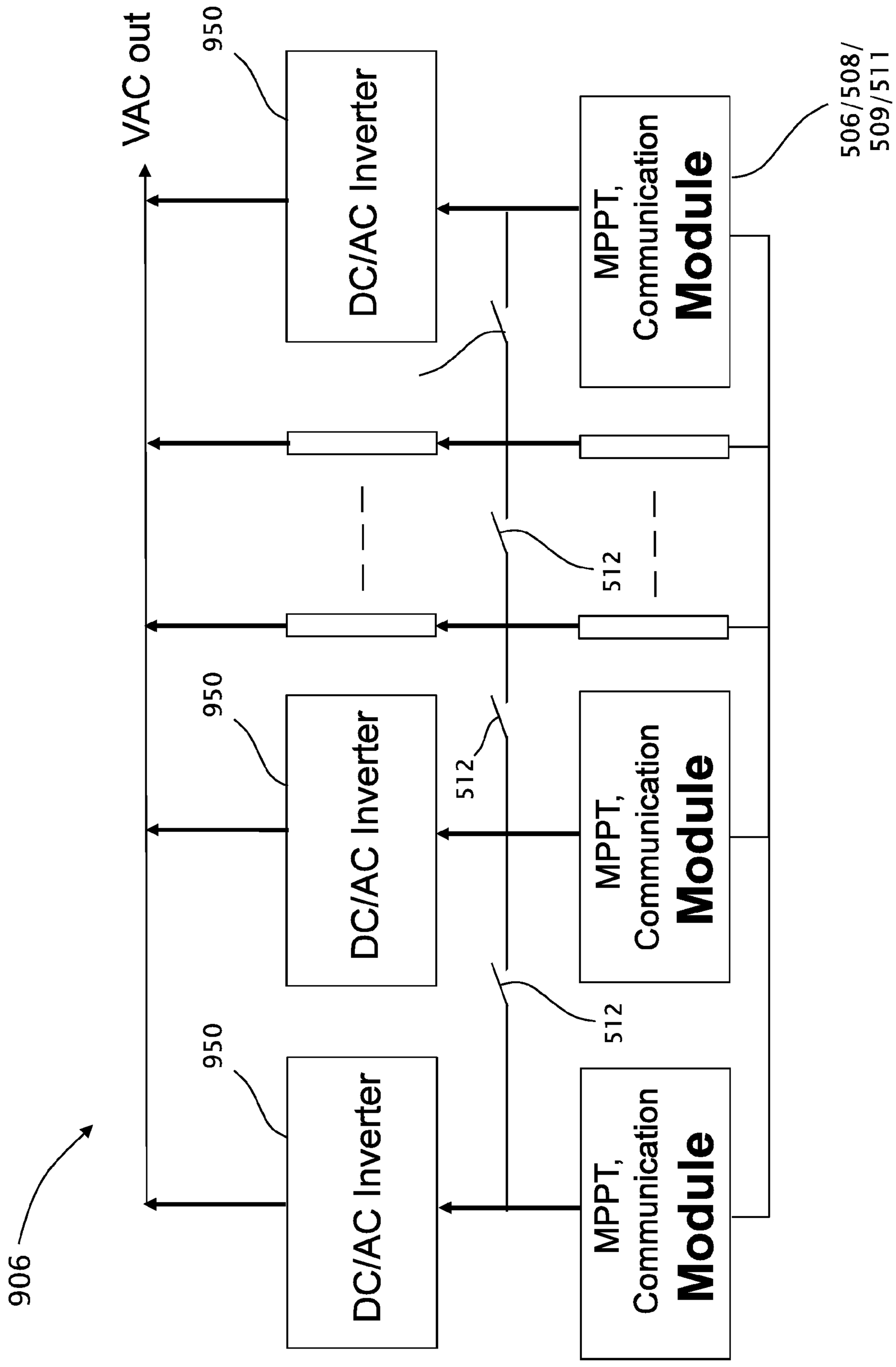

VAC out
950
DC/AC Inverter
MPPT,
Communication
Module
506/508/
509/511
512
906

Fig. 13d

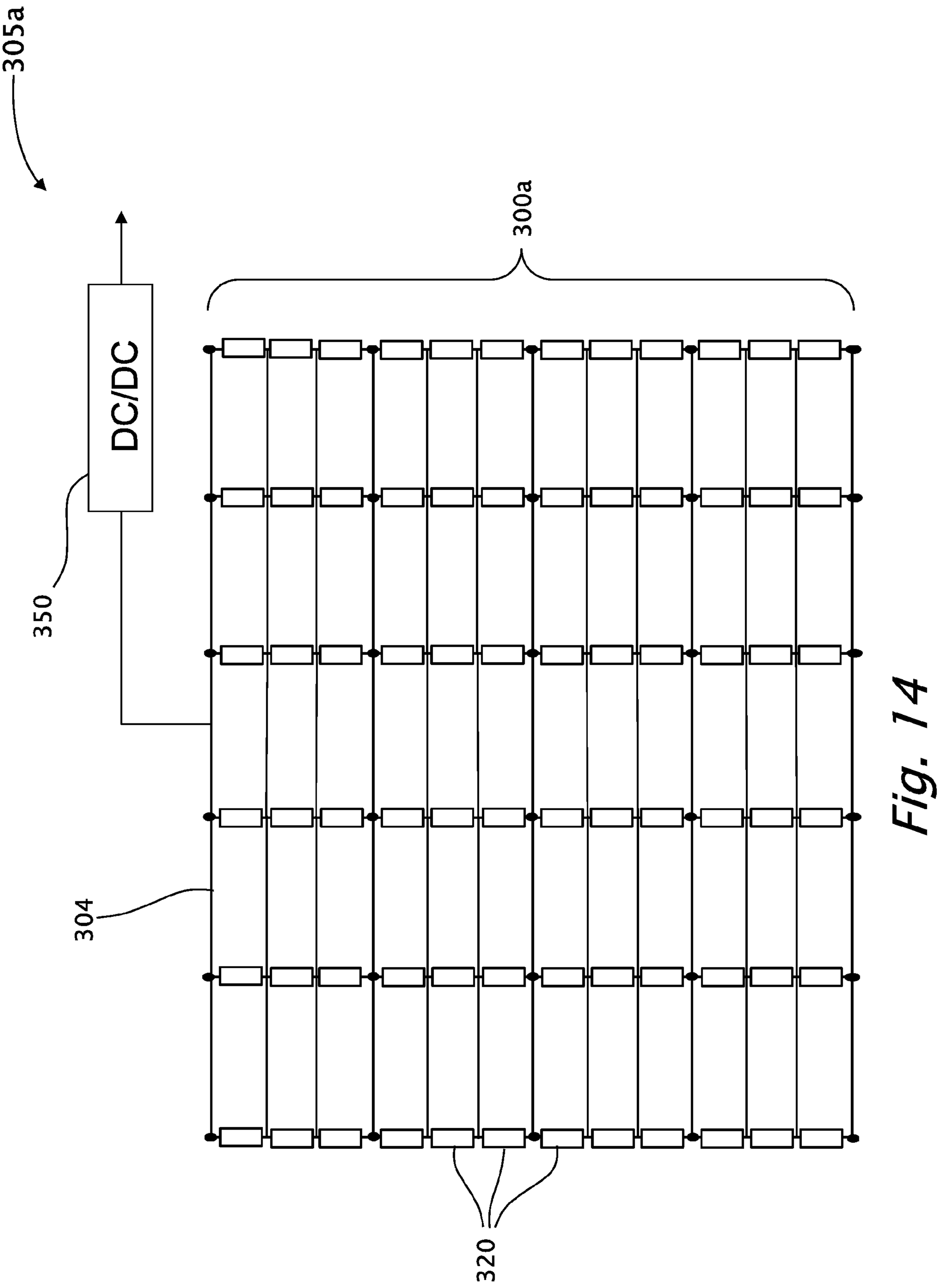


Fig. 14

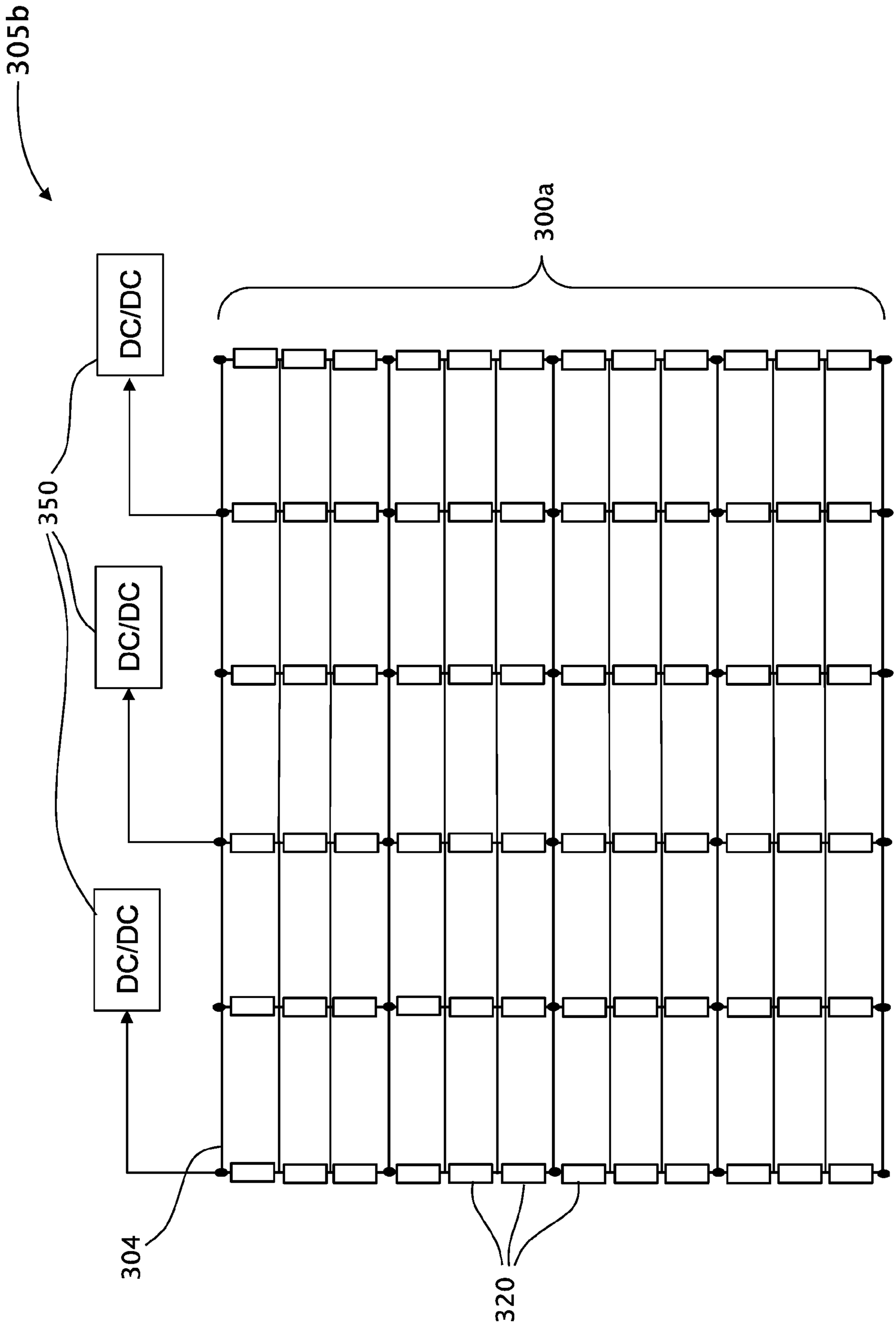


Fig. 15

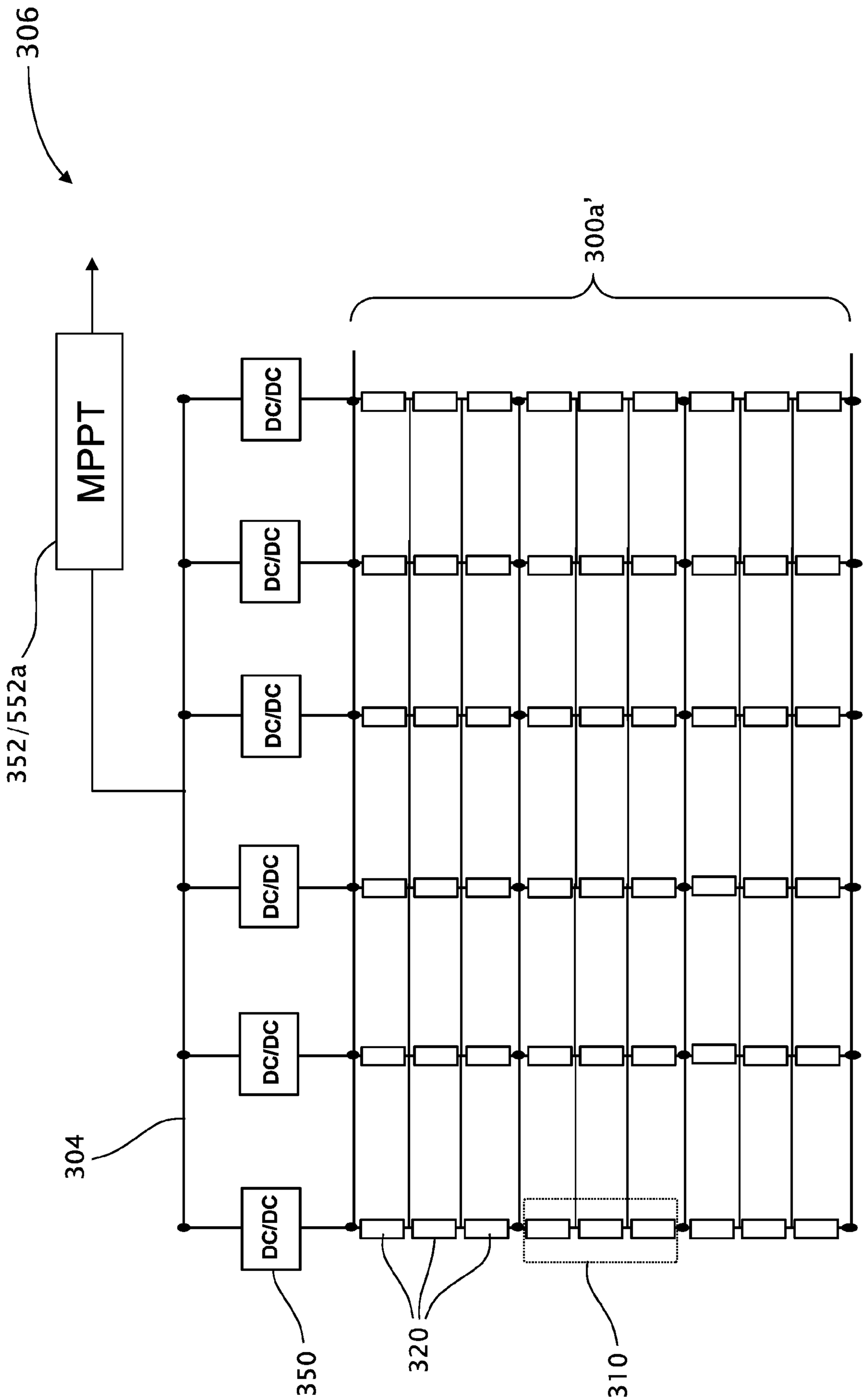

306
300
MPPT
352/552a
304
DC/DC
DC/DC
DC/DC
DC/DC
DC/DC
DC/DC
350
320
310

Fig. 16

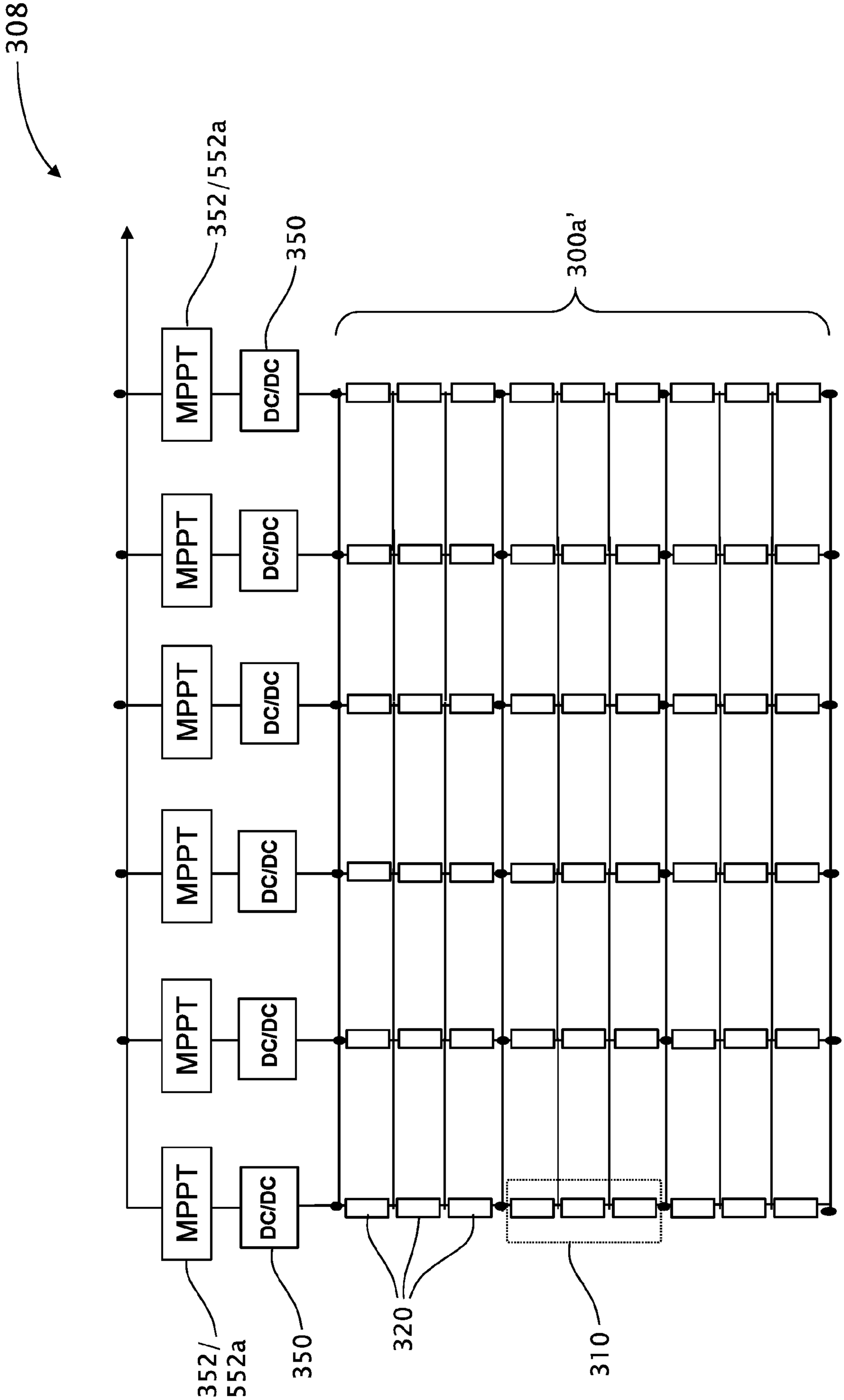


Fig. 17

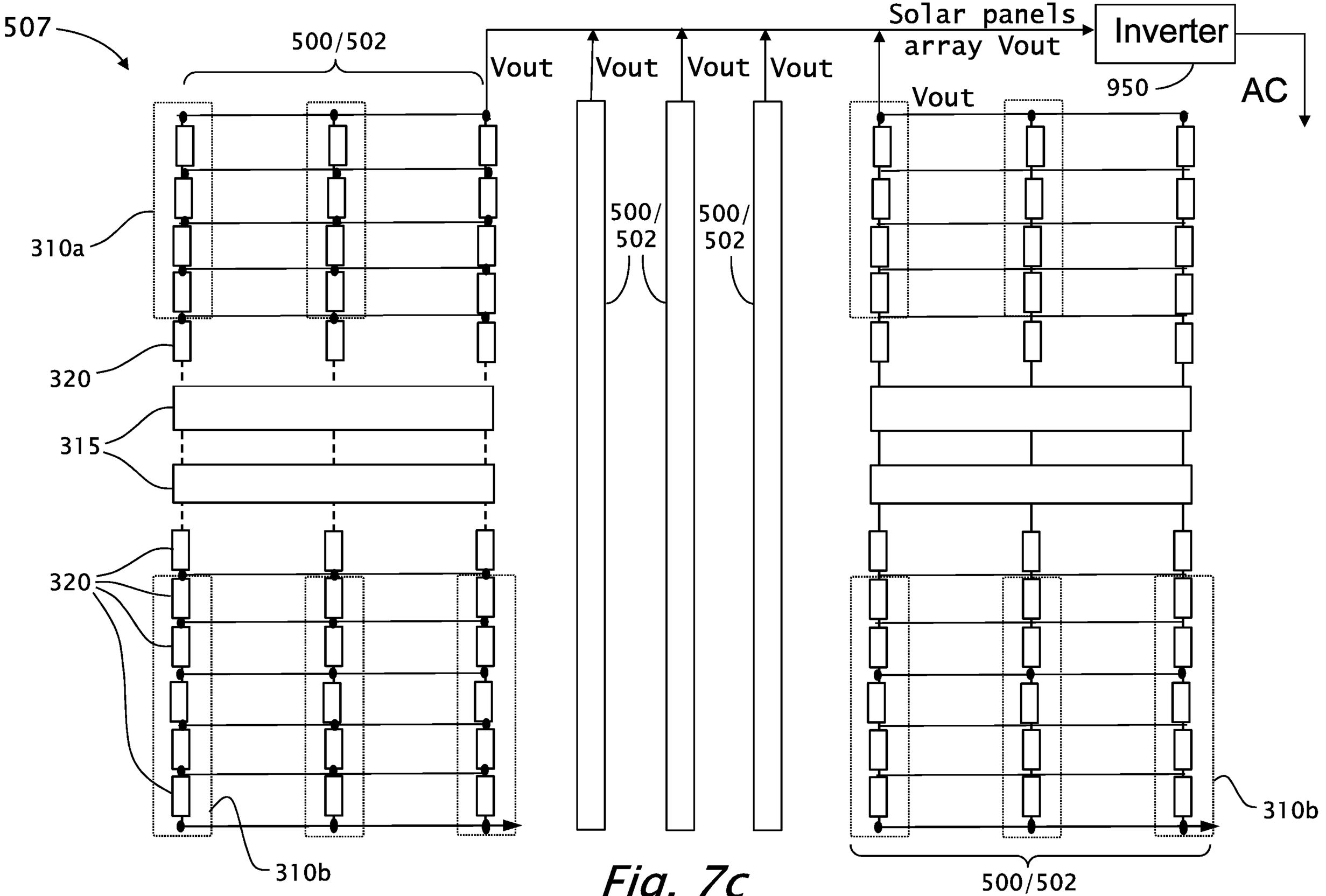

507
500/502
Vout
Vout
Vout
Vout
Solar panels
array Vout
Inverter
950
AC
Vout
310a
500/
502
500/
502
320
315
320
310b
310b
500/502

Fig. 7c