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Rotzoll et al.(10) **Pub. No.: US 2008/0283118 A1**(43) **Pub. Date: Nov. 20, 2008**(54) **PHOTOVOLTAIC AC INVERTER MOUNT
AND INTERCONNECT****Related U.S. Application Data**

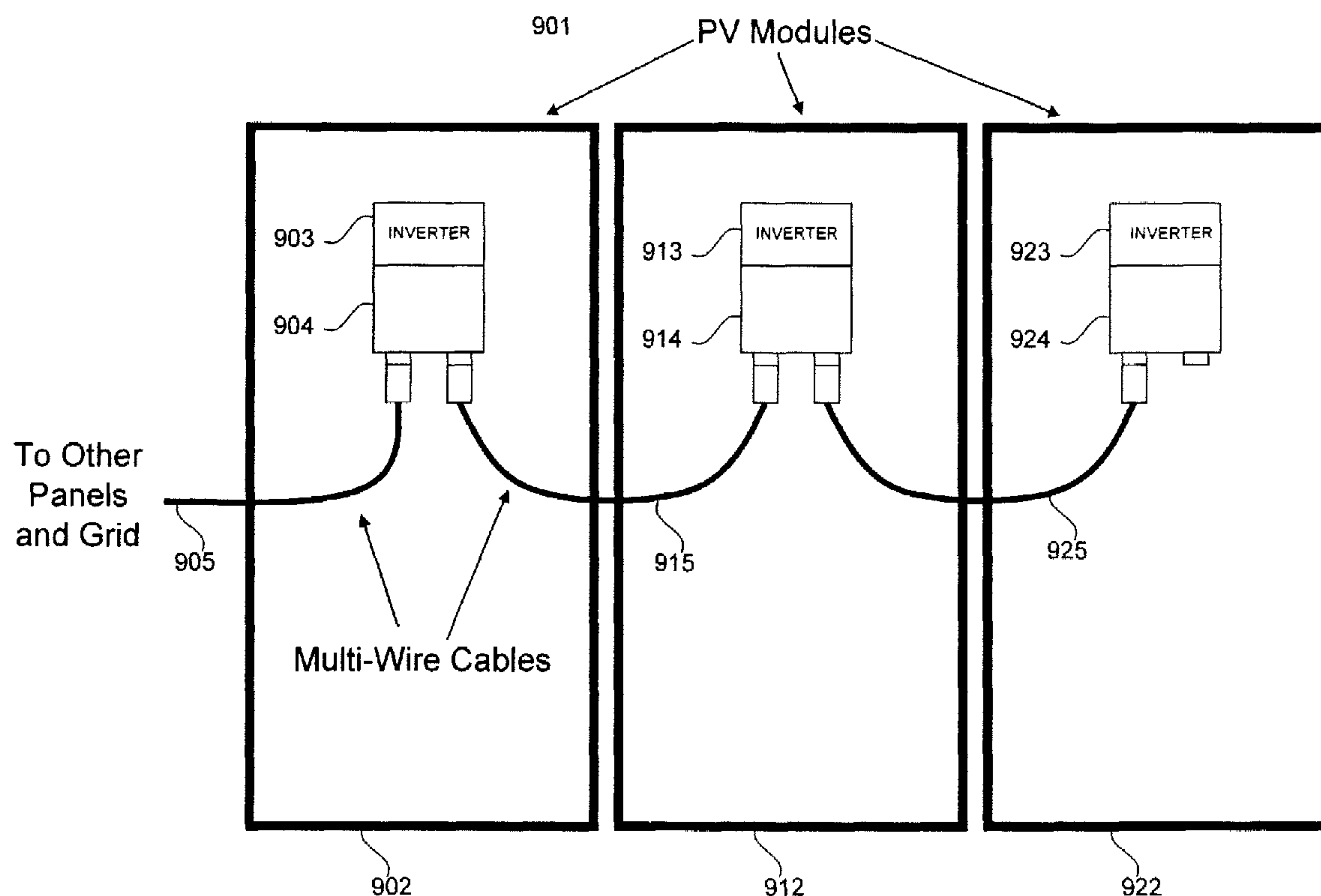
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DENVER, CO 80202 (US)**(57) **ABSTRACT**

A replaceable photovoltaic inverter is mounted on each of a plurality of photovoltaic module for the conversion of direct current, produced by the photovoltaic cells, to alternating current. The inverter is coupled to a mounting bracket on the photovoltaic module such that is can be easily replaced. Replacement of an individual photovoltaic module inverter can occur during continuous operation of the photovoltaic module system with minimal impact on overall power production. The inverter is also mounted apart from the photovoltaic module to facilitate heat transfer generated by operation of the inverter.

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CO (US)(21) Appl. No.: **12/121,578**(22) Filed: **May 15, 2008**

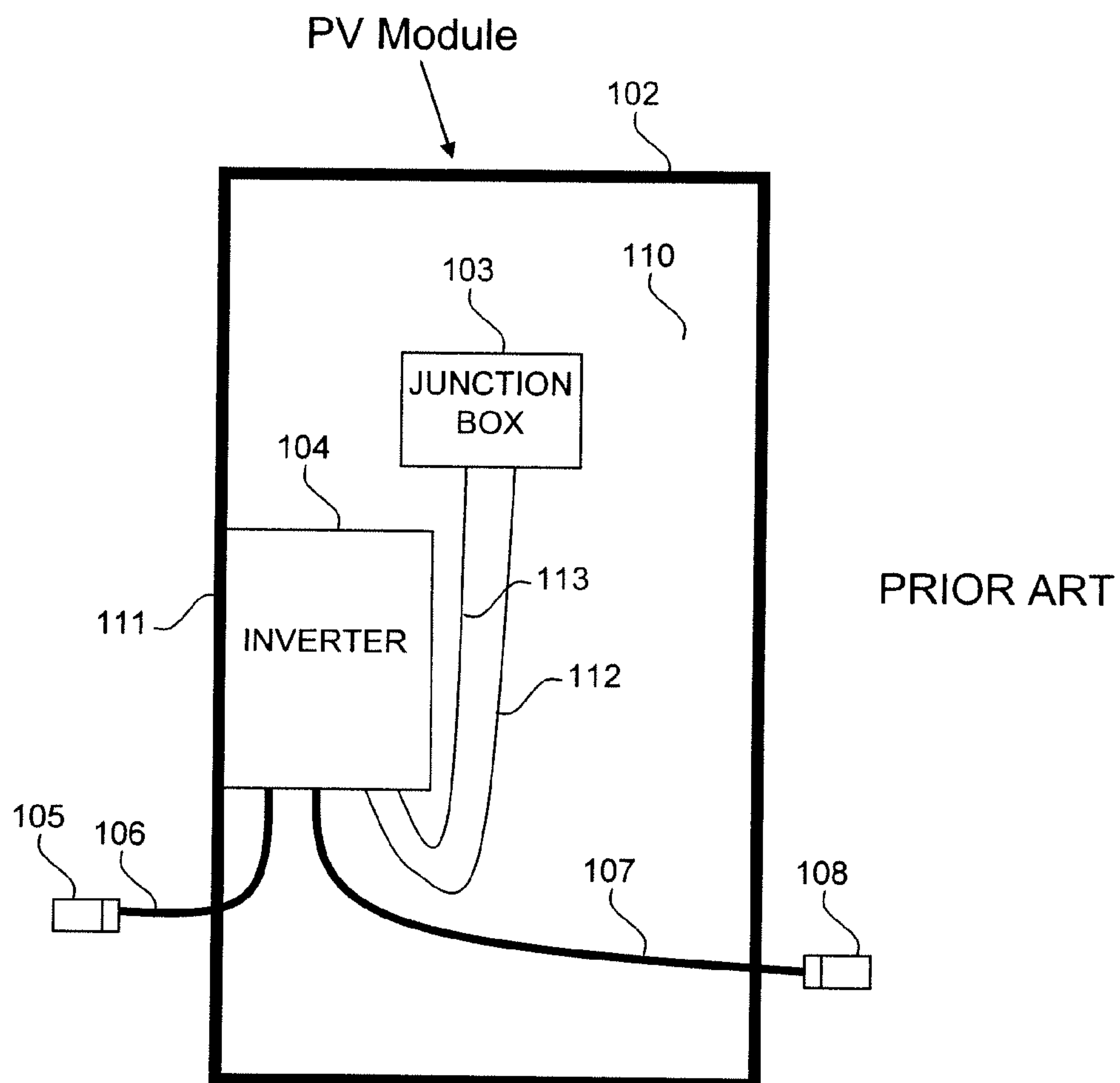


FIG. 1

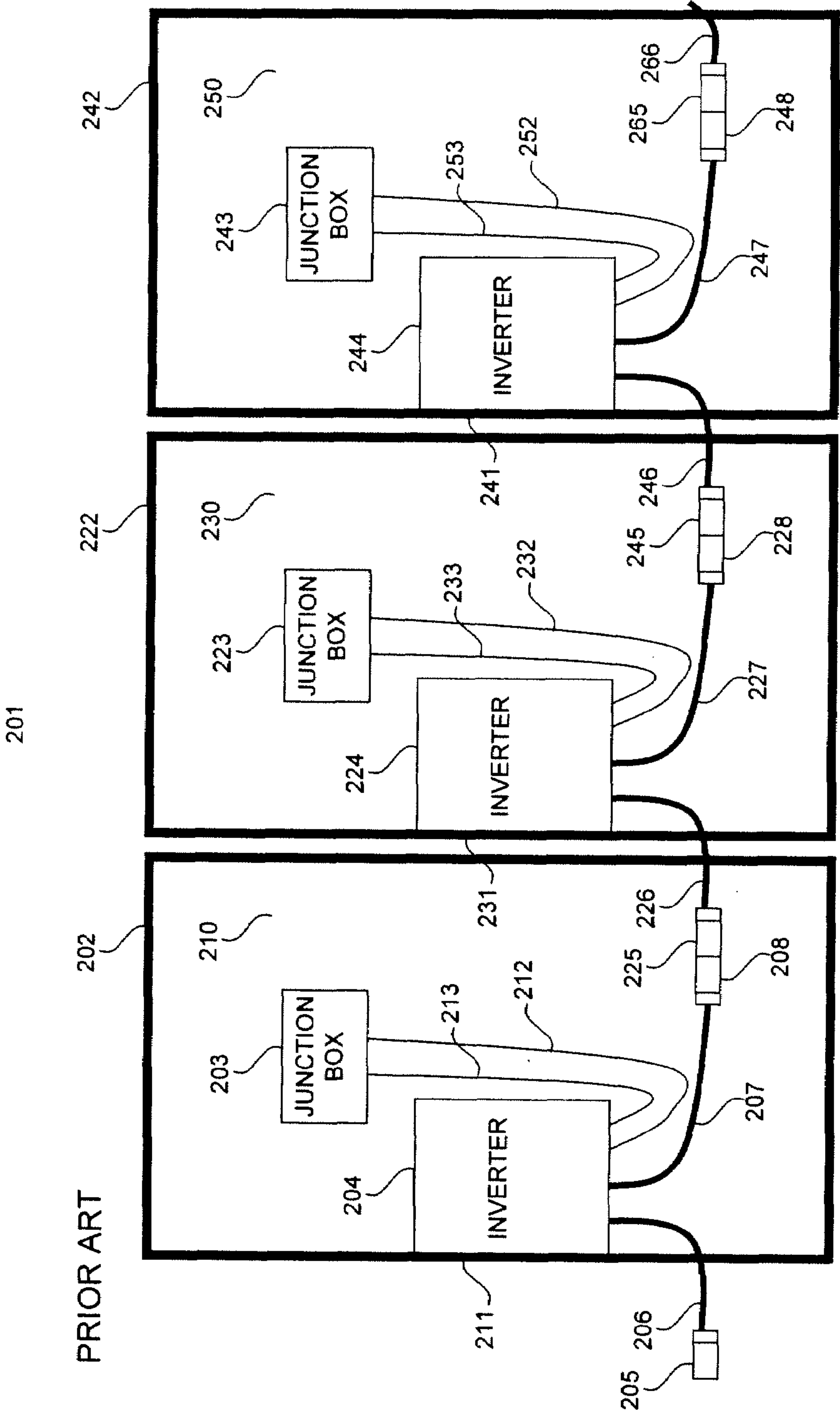


FIG. 2

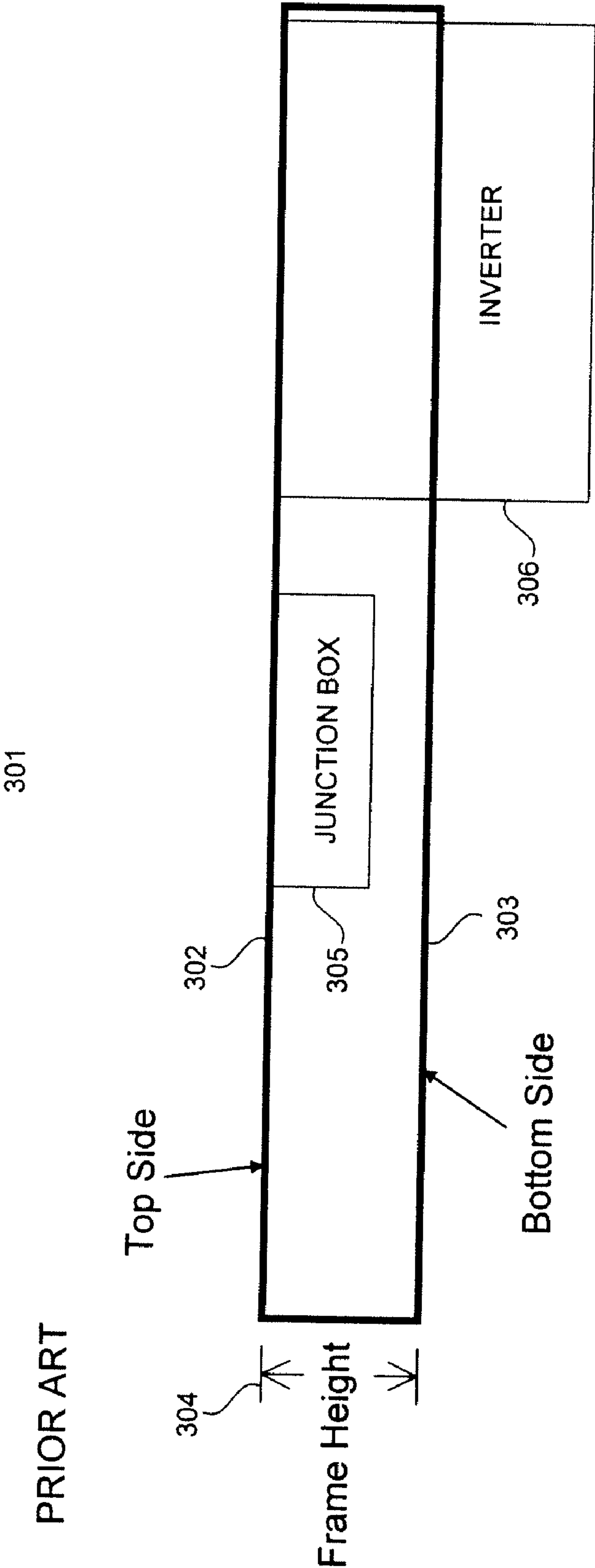


FIG. 3

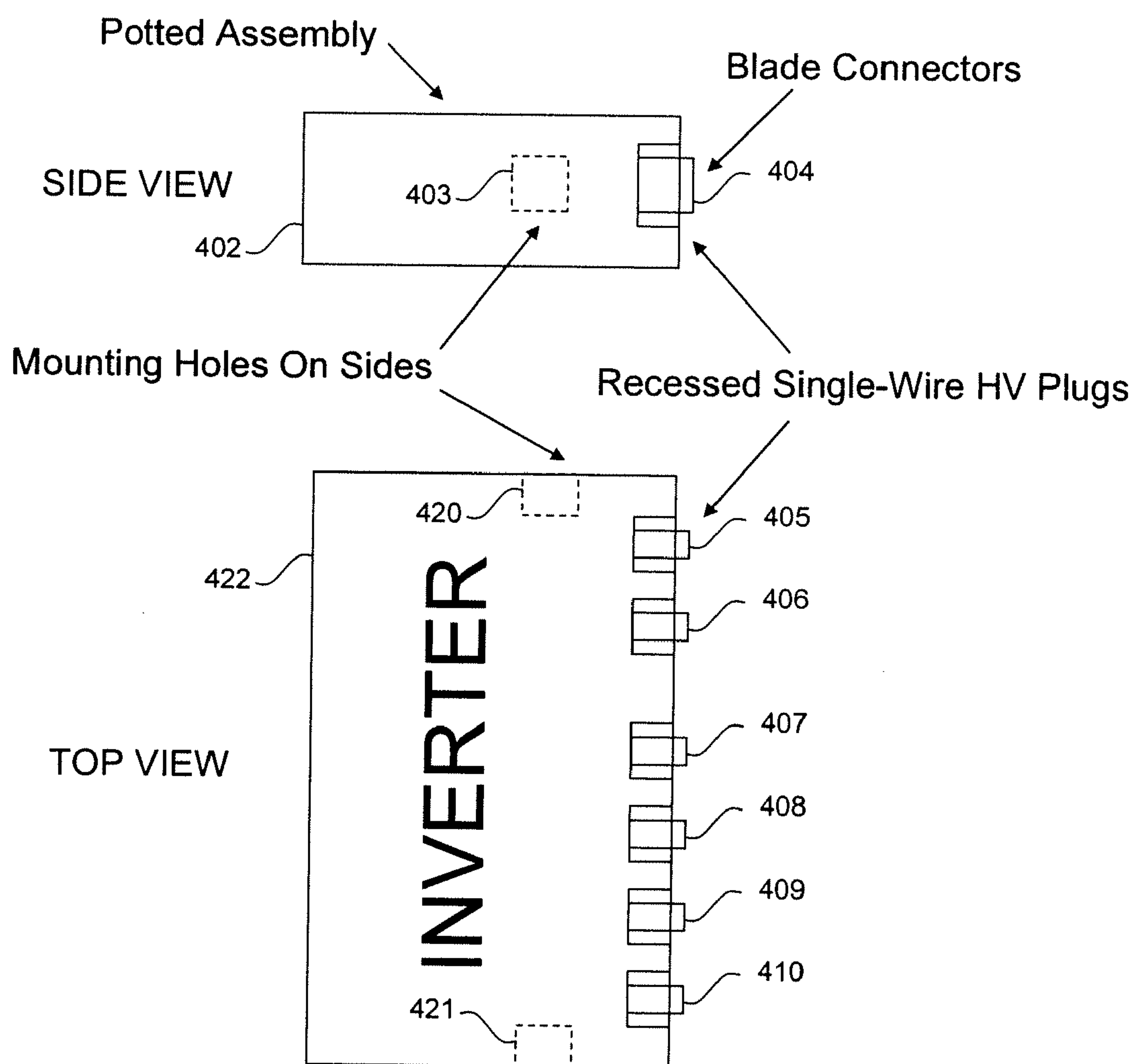


FIG. 4

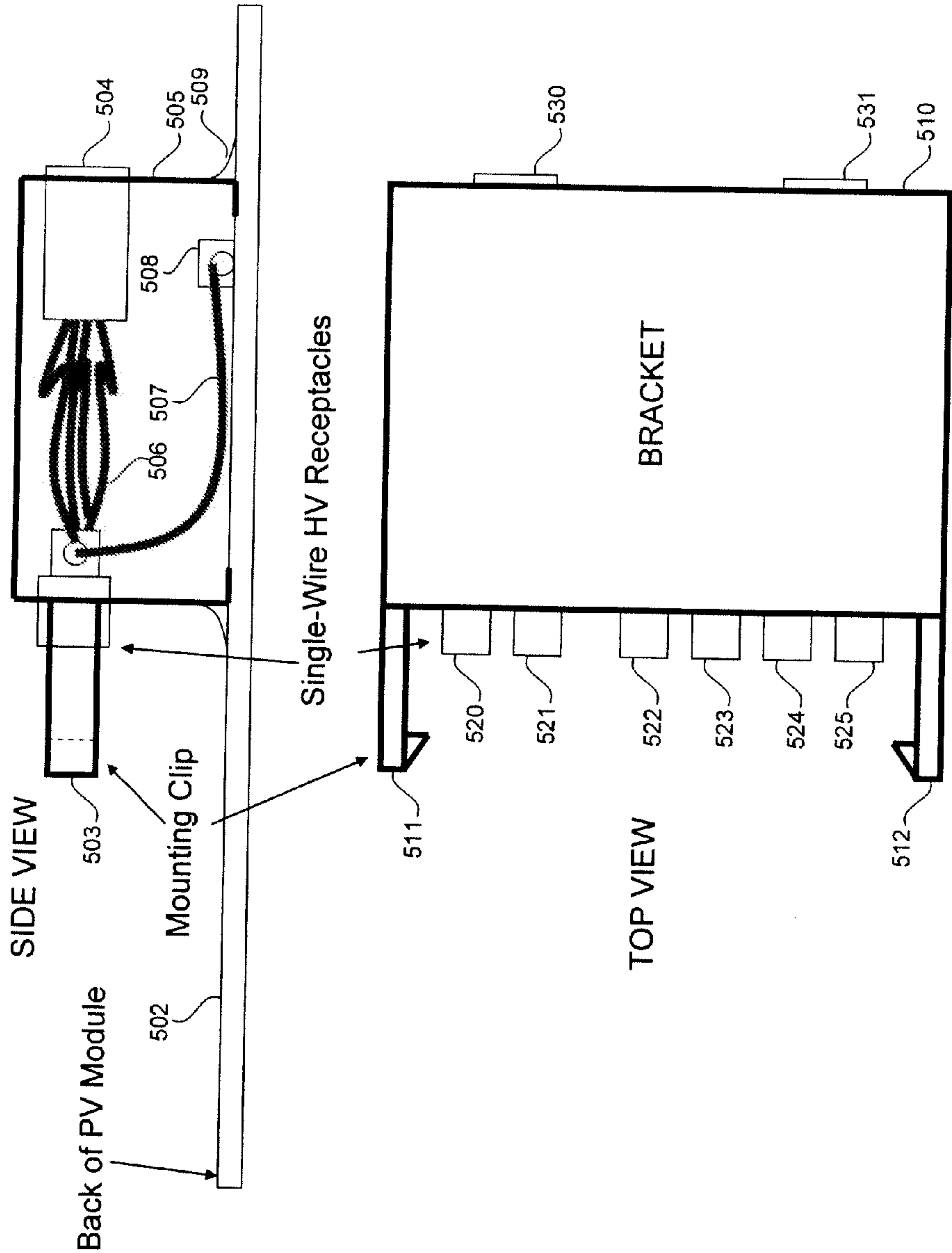


FIG. 5

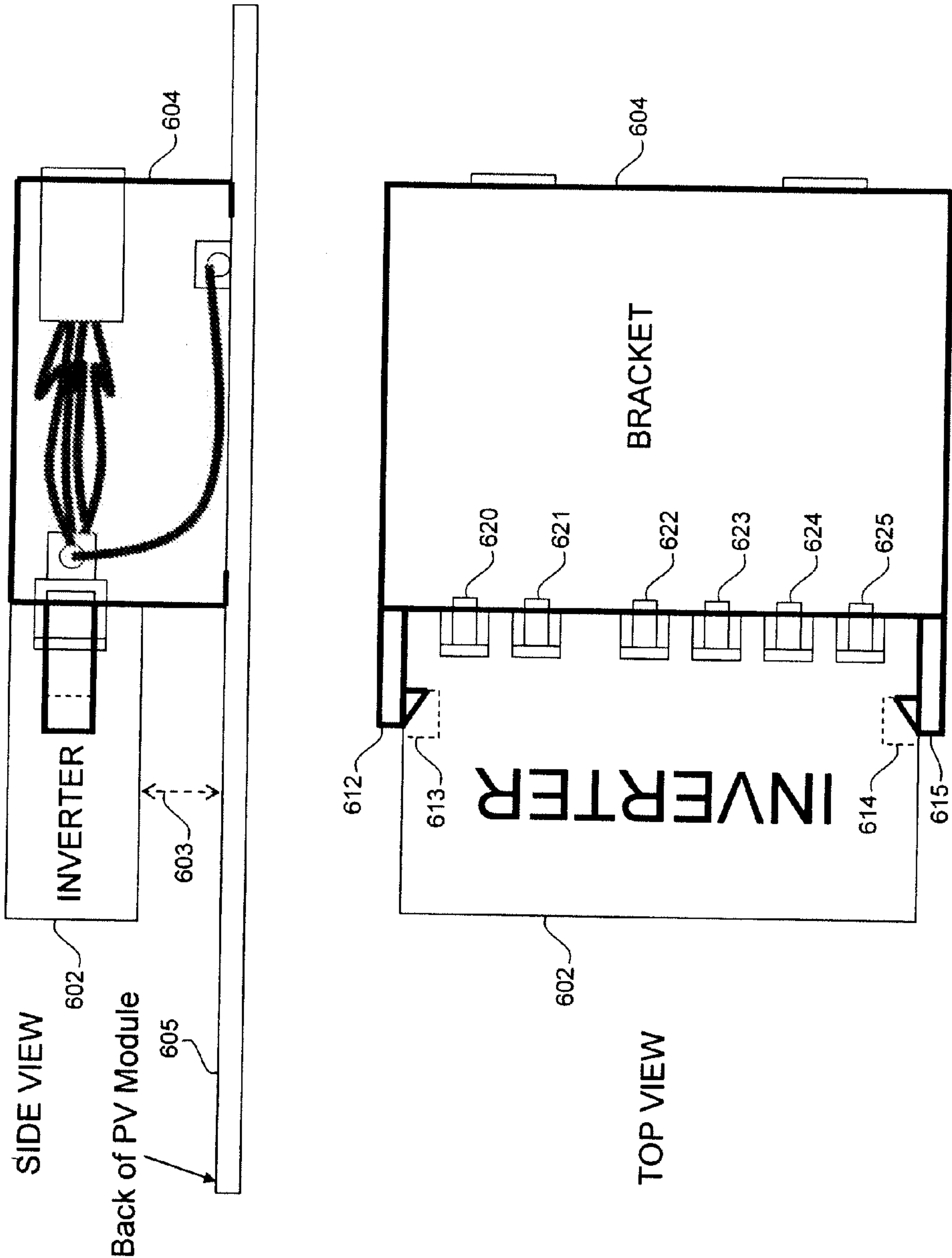


FIG. 6

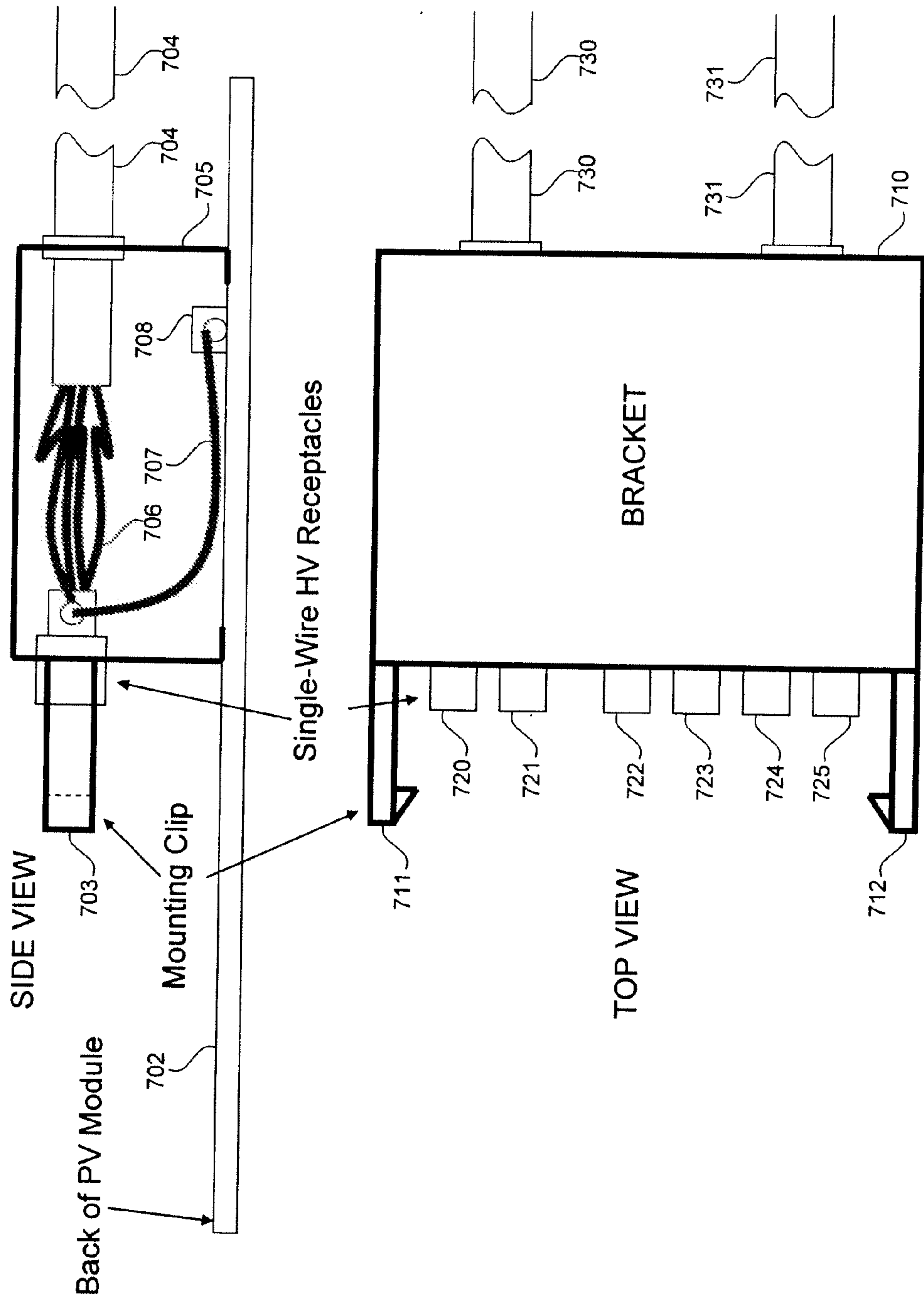


FIG. 7

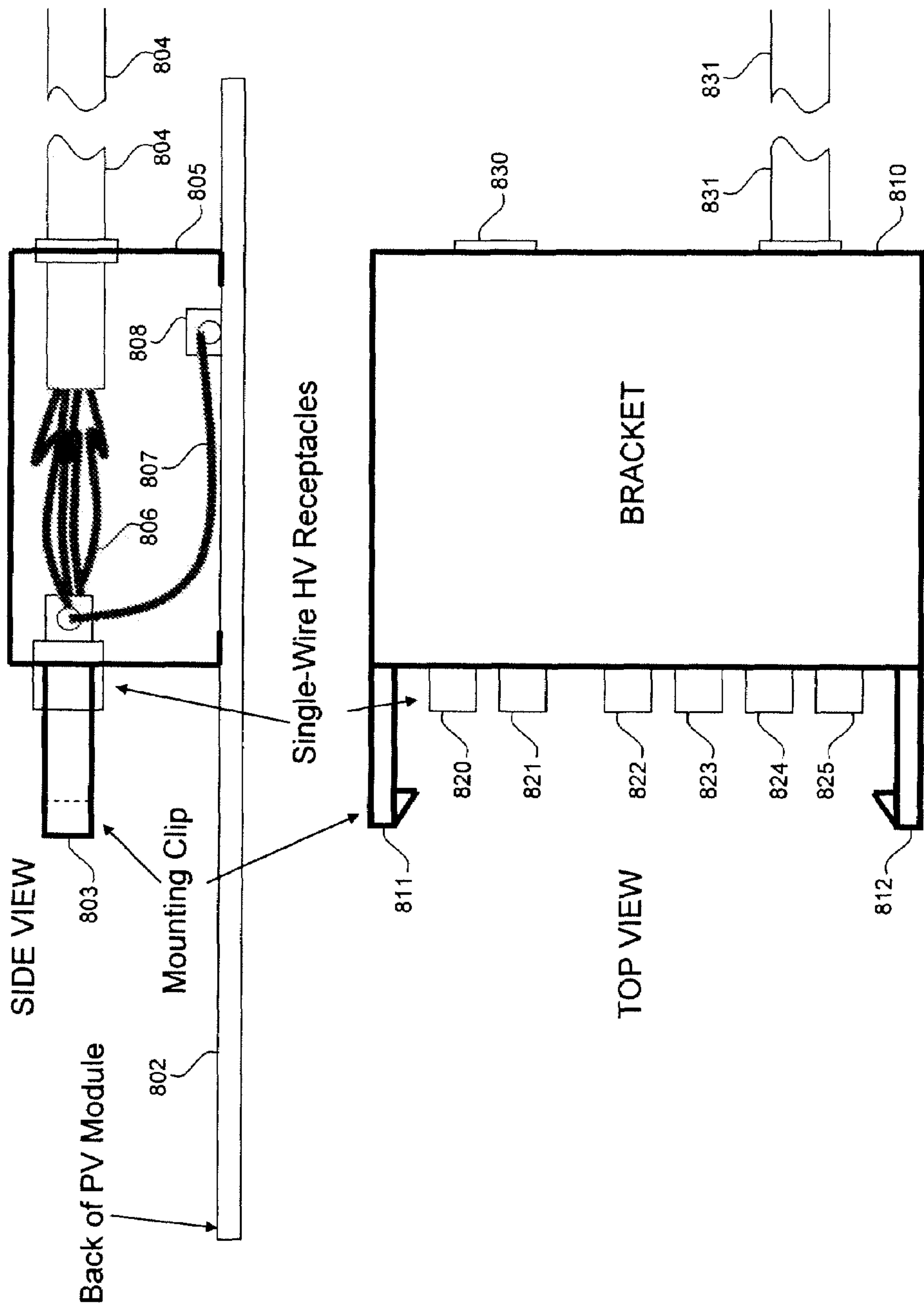


FIG. 8

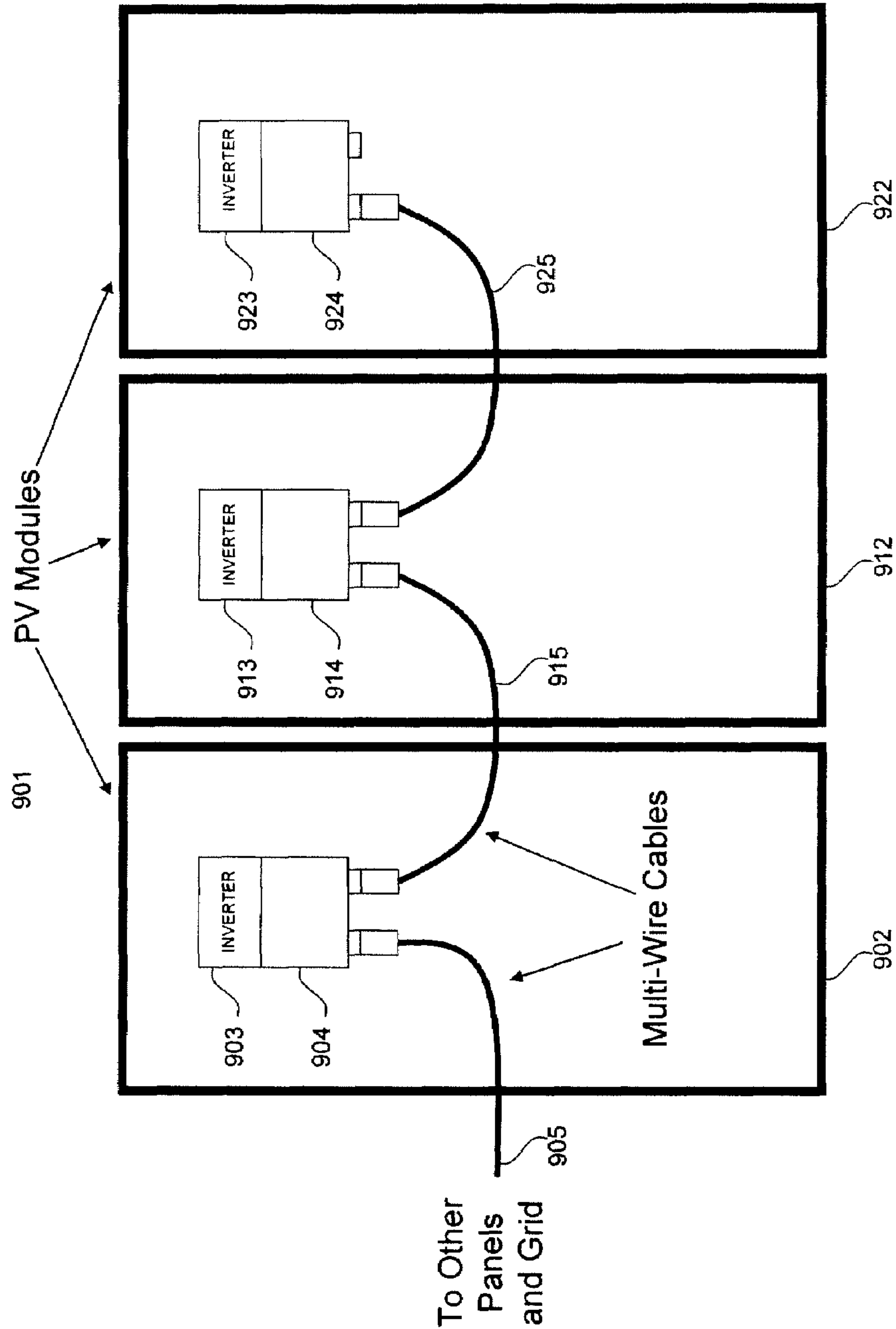


FIG. 9

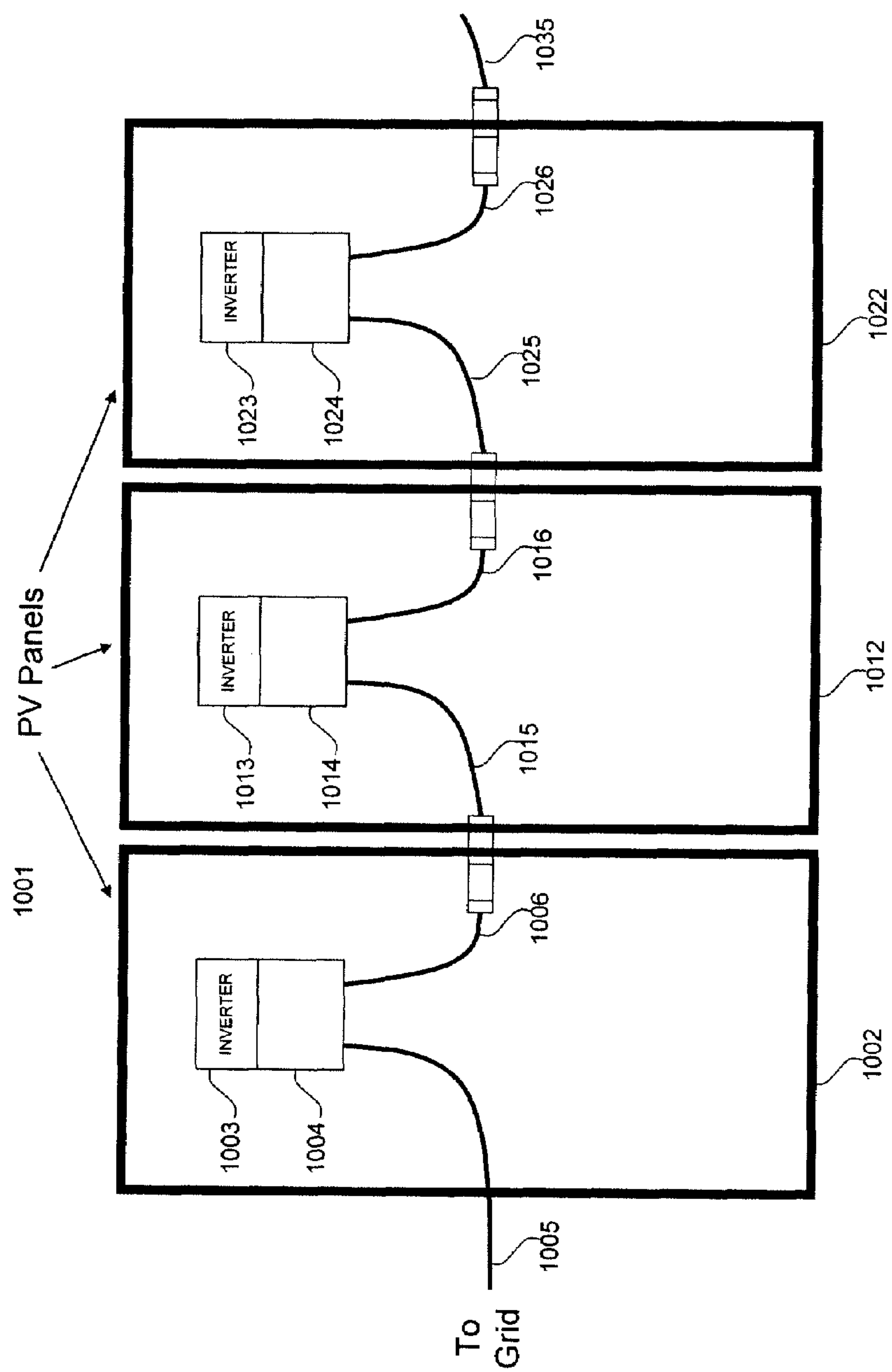


FIG. 10

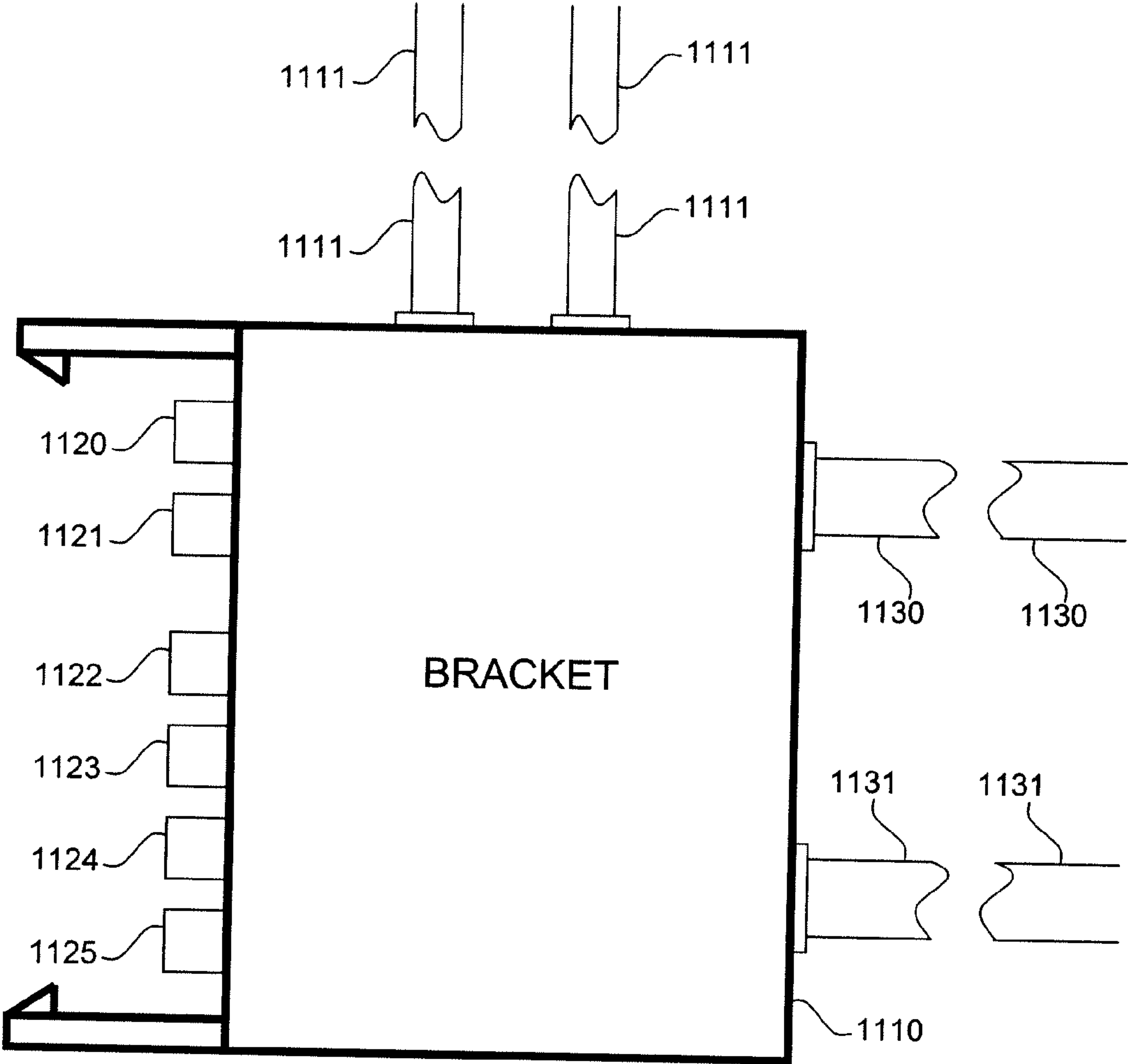


FIG. 11

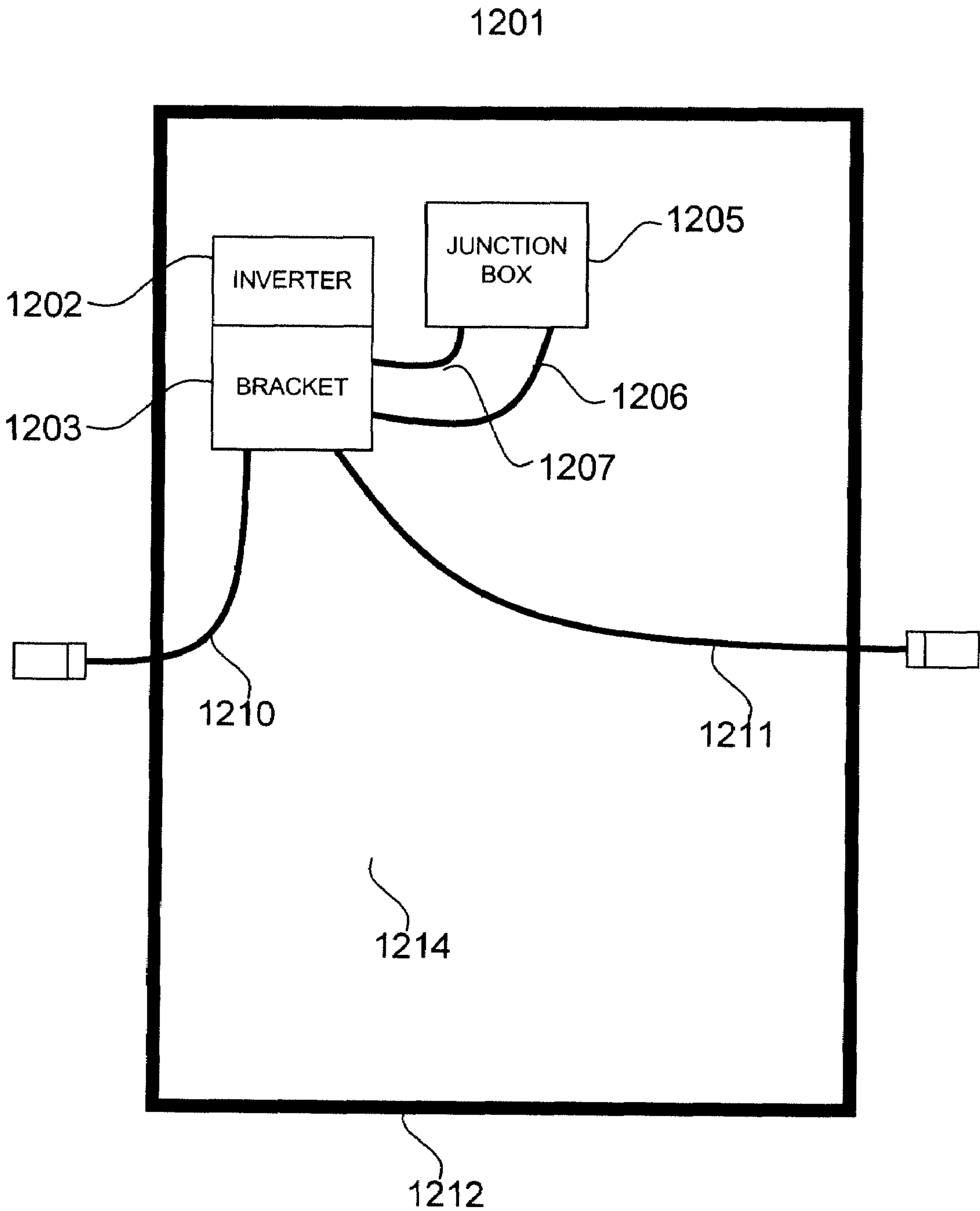


FIG. 12

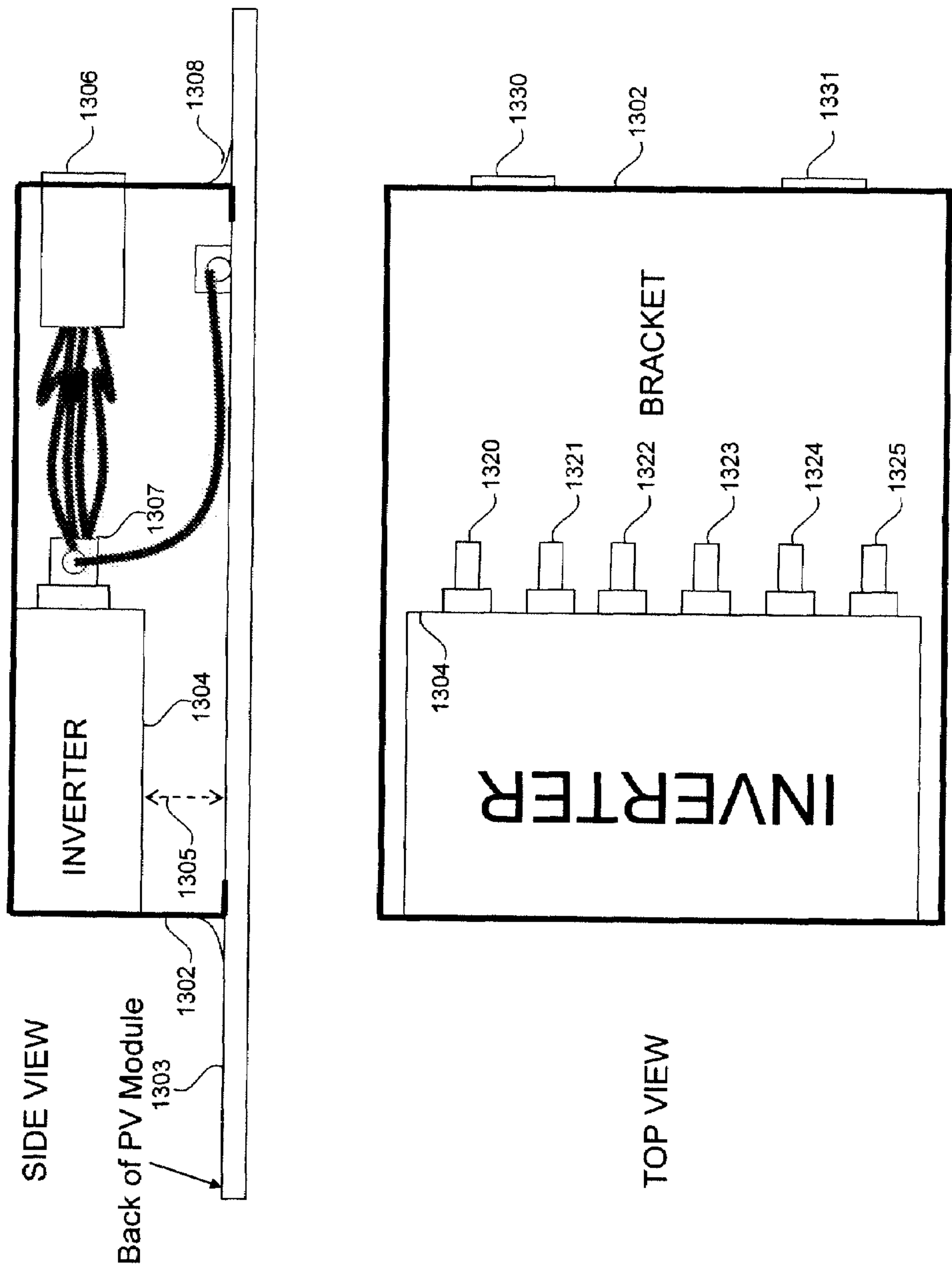


FIG. 13

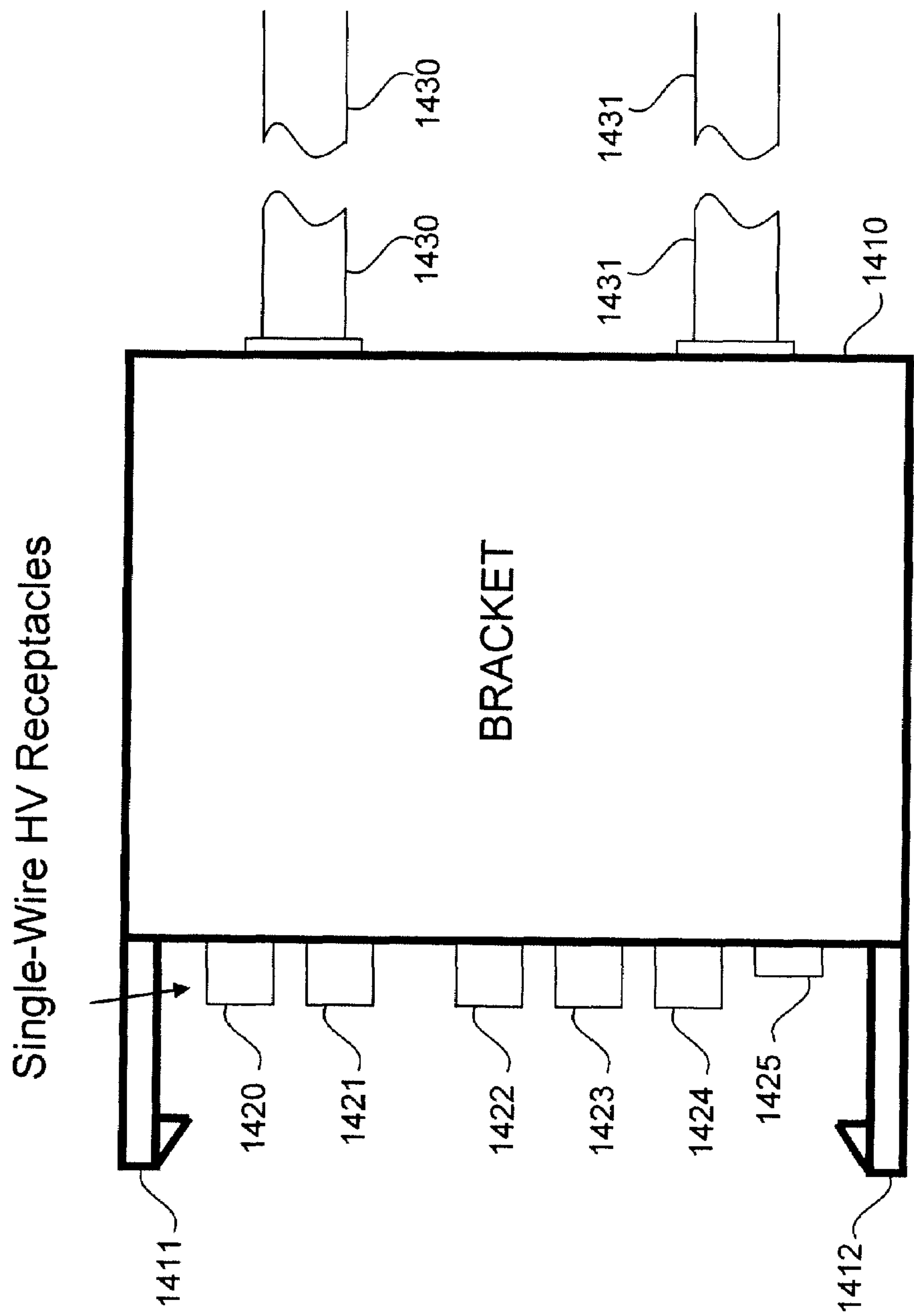


FIG. 14

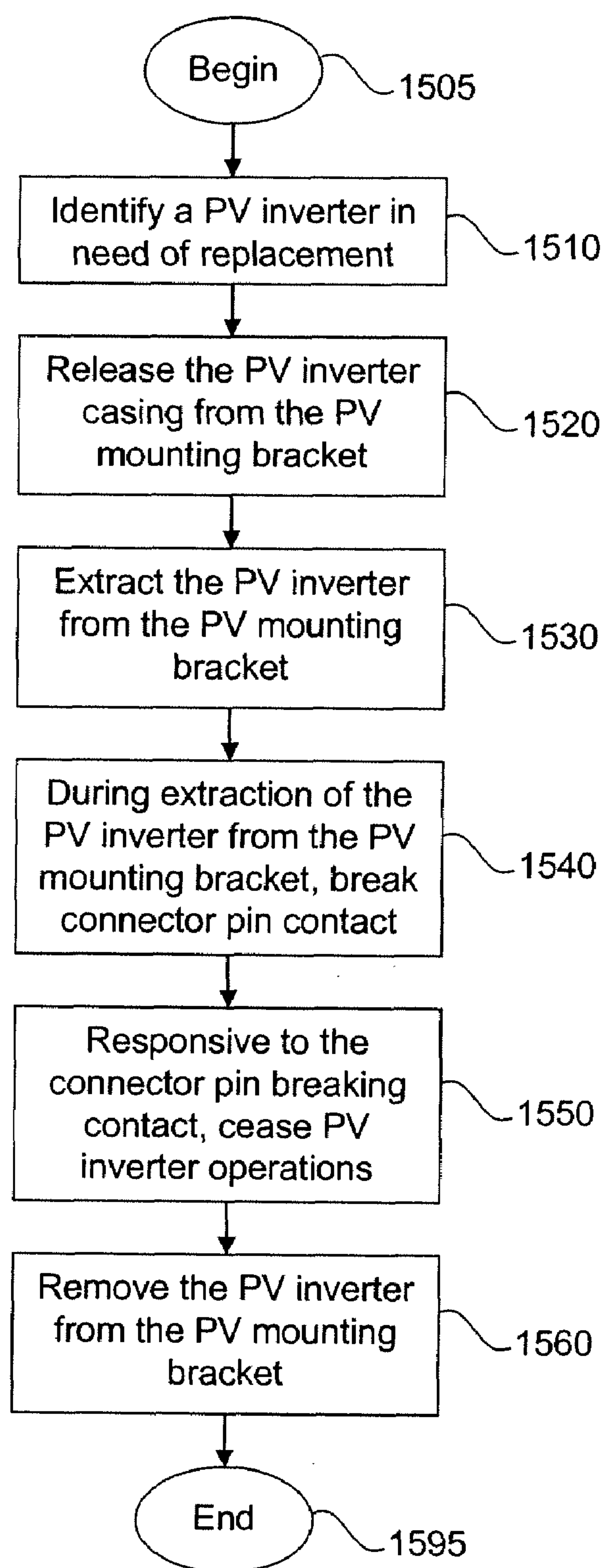


FIG. 15

PHOTOVOLTAIC AC INVERTER MOUNT AND INTERCONNECT

RELATED APPLICATION

[0001] The present application relates to and claims the benefit of priority to U.S. Provisional Patent Application No. 60/938,663 filed May 17, 2007, which is hereby incorporated by reference in its entirety for all purposes as if fully set forth herein. The present application is further related to co-pending U.S. Patent Application Ser. No. LAR003 entitled, "Photovoltaic Module-Mounted AC Inverter" and U.S. Patent Application Ser. No. LAR002 entitled "Distributed Inverter and Intelligent Gateway", both of which are hereby incorporated by this reference in their entirety.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The invention relates to electrical current power conversion and, more particularly, to a mount for an inverter configured to convert photovoltaic module output power into alternating current.

[0004] 2. Relevant Background

[0005] An inverter is a device that converts direct current ("DC") into alternating current ("AC"). Inverters can be designed to supply power from photovoltaic ("PV") modules to a utility power grid, also referred to herein as the "grid." This process places several special constraints on the power conversion process. Existing photovoltaic inverters generally fall into the category of centralized inverters wherein a single inverter performs power conversion of the DC supplied by a group of PV modules into the desired AC grid.

[0006] Another category of inverters is known as distributed inverters. A distributed inverter uses multiple inverters to generate the desired AC power from a number of PV modules. When the inverter is mounted on the PV module, the assembly comprising the PV module and inverter is termed an AC module. Previous attempts at development and marketing of AC modules have met with little success. One reason for this failure has been that the sales volume was too low to achieve any kind of economies of scale. Additionally, the components used in the distributed inverters associated with AC modules were off-the-shelf and, in many cases, were not optimized for the rigors of supplying AC power to the grid. The reliability levels of existing off-the-shelf components used in the inverters limits their lifetime to between five and ten years. Additionally, there can be up to 1000 components in an inverter resulting in significant cost per unit of energy. Furthermore, the complexity and system requirements of such an inverter result in a cumbersome package that is difficult to attach to a PV module.

[0007] Referring now to FIG. 1, the back-side 110 of a PV module 102 including a PV module-mounted inverter 104 as known in the prior art is shown. A junction box 103, normally a component of the PV module 102, is permanently attached to the PV module 102 frame via an adhesive. The junction box 103 encloses and protects the DC connections from the module 102, including bypass diodes used to shunt current around disabled or non-producing PV cells within the module. The PV module 102 DC outputs typically leave the junction box 103 via single-wire cables 112, 113 and connect to an inverter 104. The inverter 104 is mounted to the frame of PV module 102 near an edge 111 of the PV module. The weight and size of the inverter may vary, and in many instances further mea-

asures are needed to improve support to the inverter 104 including mounting it at a corner of the frame, adding metal brackets to the frame or even mounting the inverter on the members that ultimately support the PV module 102. Cables 106, 107 from the inverter connect the PV module 102 to the AC grid and to other PV module-mounted inverters via connectors 105, 108. The cables 106, 107 are connected together, according to one system of implementation and as described in related application Ser. No. _____ in parallel within the inverter 104 so that all voltages on the pins of the first connector 105 also appear on the corresponding pins of the second connector 108. The cables 106, 107 and connectors 105, 108 are typically designed to support single-phase, single pole or single-phase, two-pole AC grid interconnection, and each requires a minimum of three conductors. The connectors are defined to allow for chains of inverters to be developed in which the AC grid connection is accessible to all inverters by simply connecting the connector 108 of one inverter 104 to another connector 105 of an adjacent PV module-mounted inverter in a system. The inverter 104 typically has a metallic enclosure, requiring that an equipment grounding conductor be brought through cables 106, 107 for electrical code mandated safety ground.

[0008] Referring to FIG. 2, an array 201 of PV modules 202, 222, 242 including PV module-mounted inverters 204, 224, 244 as known in the prior art is shown. In the configuration shown, connector 205 is connected to the grid. As referred to herein the grid will be recognized by one skilled in the art of electrical generation and local electric grid systems. This grid includes not only the ability to use the power produced by the PV modules locally, for example to power a commercial enterprise or residence, but also to sell back excess or unused power to a community electric grid. The AC grid voltage appears at connector the 208 and is passed to the inverter 224 of the PV module 222 via another connector 225, which is mated with a receiving connector 208. Similarly, the same AC voltage is now available at a similar inverter 244 via the mating of a like connector 228 to another receiving connector 245. This sequence can continue until the maximum current rating of all cables 206, 207, 226, 227, 246, 247 and 266 has been exhausted.

[0009] FIG. 3 is a side end view of a PV module 301 including a PV module-mounted inverter 306 as is known in the prior art. The height of the frame 304 of the module typically measures about one inch. The junction box 305 and inverter 306 are generally attached to the top side 302 of the module 301. The height of junction box 305 typically remains below the frame height and therefore does not protrude below the lower edge of the frame 303. However, existing inverter designs are considerably taller than the frame height 304 due to their complexity and protrude below the module frame. Since PV modules are typically stacked frame-to-frame, a tall inverter impedes pre-assembly of the inverter to the PV module prior to shipment and severely impacts the ability to service a PV module or inverter in the field should one fail after installation.

[0010] Additionally, existing designs of PV module-mounted inverters present significant reliability problems. Inverters occasionally fail. When such an event occurs the PV module to which it is attached is no longer contributing in the production of electricity for the system. The identification of that singular PV module failure, however, is extremely difficult as there is no outright indication that a PV module has failed. Generally the only indication of a PV module failure is

a decrease in power production. This is compounded with the fact that each PV module and its installation in a system represents a significant capital outlay. A failure of an inverter, should it be identified, results in the replacement of the entire PV module. To do such a repair, under the systems and inverters currently used in the prior art, the entire PV system must be taken off line. Not only is the replacement of the entire PV system costly, but the loss in power production of at least a significant portion of the entire PV system while a single module is replaced is inefficient.

[0011] The weight, size, metallic enclosure and relatively low efficiency of the existing inverter designs result in a more complex mounting arrangement and a considerable increase in cost over a centralized inverter approach. But a centralized inverter is also not an optimal solution. Yet, the benefits of maximum power-point tracking optimization normally achieved by having an inverter at each PV module easily can be lost by a lack of power efficiency. Also the lifetime of an inverter is less than that of a PV module; therefore, any inverter mounted onto a PV module in a distributed model will need replacement at some point during the life of the PV module. Finally, existing inverters are difficult to replace due to their weight, anchoring schemes and wiring.

[0012] An efficient inverter that creates little heat, is light-weight in construction, is easily replaced and minimizes exposed wiring remains a challenge. Compounding this challenge is that such an invention should also minimize system cost and easily fit within the depth of the PV module frame. These and other deficiencies of the prior art are addressed by embodiments of the present invention.

SUMMARY OF THE INVENTION

[0013] According to one embodiment of the present invention, a replaceable PV module-mounted AC inverter is designed to be inserted into an inverter mounting bracket. The inverter mounting bracket is attached to the back of a PV module via adhesive of some other means. The inverter and inverter mounting bracket are made of non-conducting materials to remove electrical code requirements for equipment grounding conductors. The inverter is coupled to the bracket via locking mounting clips on the inverter mounting bracket that lock into inverter mounting recesses. No tools are required to insert the inverter into the bracket and only a simple blade screwdriver is required to release the clips for removal and replacement of the inverter.

[0014] According to one embodiment of the present invention, the inverter is spaced from the back surface of the PV module to minimize heating of the PV module by the inverter and to provide for convective air flow surrounding the inverter to dissipate heat generation. Furthermore, the inverter can be replaced while the PV module and indeed the entire PV module system remains operational. According to one embodiment of the present invention, by virtue of the joining mechanism of the inverter to the PV module bracket, an inverter can safely be removed from the bracket/interconnect with minimal fear of an arc and without disrupting the production of power from the remaining PV modules.

[0015] There are, according to one embodiment, two inverter mounting bracket AC connections to support daisy-chain connections between multiple AC modules. The AC connections can be made using bracket mounted connectors or by using cables affixed to the bracket. Finally, AC connections can be a combination of one affixed cable and one bracket-mounted connector.

[0016] The inverter mounting bracket DC connections, according to one embodiment of the present invention, can be implemented inside the bracket by mounting the bracket on top of the DC connections of a PV module. Additional external single-wire cables can be added to accommodate connection to an existing junction box mounted on a PV module.

[0017] For applications requiring permanent inverter installation without the capability of field replacement of the inverter, the inverter can be completely enclosed by the bracket to result in a very reliable and low-cost bracket implementation. By removing the interface between the bracket and the inverter, the reliability of the PV module is enhanced at the cost of the flexibility to replace an inverter in the field.

[0018] The features and advantages described in this disclosure and in the following detailed description are not all-inclusive. Many additional features and advantages will be apparent to one of ordinary skill in the relevant art in view of the drawings, specification, and claims hereof. Moreover, it should be noted that the language used in the specification has been principally selected for readability and instructional purposes and may not have been selected to delineate or circumscribe the inventive subject matter; reference to the claims is necessary to determine such inventive subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] The aforementioned and other features and objects of the present invention and the manner of attaining them will become more apparent, and the invention itself will be best understood, by reference to the following description of a preferred embodiment taken in conjunction with the accompanying drawings, wherein:

[0020] FIG. 1 is a layout diagram of the back-side of an AC module as is known in the prior art;

[0021] FIG. 2 is a layout diagram of the back side of an AC PV module system as is known in the prior art;

[0022] FIG. 3 is a side end view schematic of an AC module as is known in the prior art;

[0023] FIG. 4 is a mechanical drawing of an inverter according to one embodiment of the present invention;

[0024] FIG. 5 is a mechanical drawing of an inverter mounting bracket according to one embodiment of the present invention;

[0025] FIG. 6 is a mechanical drawing of an inverter inserted into an inverter mounting bracket according to one embodiment of the present invention;

[0026] FIG. 7 is a mechanical drawing of a an inverter mounting bracket according to one embodiment of the present invention;

[0027] FIG. 8 is a mechanical drawing of a an inverter mounting bracket according to one embodiment of the present invention;

[0028] FIG. 9 is a layout drawing of the placement of inverters, inverter mounting brackets, associated AC cables and PV modules according to one embodiment of the present invention;

[0029] FIG. 10 is layout drawing of the placement of inverters, inverter mounting brackets, associated AC cables and PV panels according to one embodiment of the present invention;

[0030] FIG. 11 is a mechanical drawing of a an inverter mounting bracket according to another embodiment of the present invention;

[0031] FIG. 12 is a layout drawing of the placement of an inverter mounting bracket, inverter and associated AC and

DC cables on the back of a PV module with a junction box according to one embodiment of the present invention;

[0032] FIG. 13 is a mechanical drawing of an inverter mounting bracket with an enclosed inverter according to one embodiment of the present invention;

[0033] FIG. 14 is a mechanical drawing of an inverter mounting bracket with a recessed pin to enable power-on replacement of the inverter, according to one embodiment of the present invention; and

[0034] FIG. 15 is a flowchart showing one method embodiment for removing a PV inverter from a fully operational PV module.

[0035] The Figures depict embodiments of the present invention for purposes of illustration only. One skilled in the art will readily recognize from the following discussion that alternative embodiments of the structures and methods illustrated herein may be employed without departing from the principles of the invention described herein.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0036] Specific embodiments of the present invention are hereafter described in detail with reference to the accompanying Figures. Like elements in the various Figures are identified by like reference numerals for consistency. Although the invention has been described and illustrated with a certain degree of particularity, it is understood that the present disclosure has been made only by way of example and that numerous changes in the combination and arrangement of parts can be resorted to by those skilled in the art without departing from the spirit and scope of the invention.

[0037] Referring now to FIG. 4, a mechanical drawing including a side 402 and top view 422 of a removable PV module-mounted power element according to a one embodiment of the present invention is shown. According to one embodiment of the present invention the power element 422 can be an inverter capable of converting DC power to AC power. In another embodiment of the present invention the power module is a DC conditioner capable of modifying the DC characteristics including, but not limited to voltage. While the present invention is hereafter described in terms of an inverter, one skilled in the art will recognize that the power element 422 can possess multiple functionalities without departing from the spirit of the invention.

[0038] Referring again to FIG. 4, a potted assembly inverter 422 in a non-conductive enclosure is shown with metallic blade connectors 404, 405, 406, 407, 408, 409, 410 to bring AC and DC wiring connections out of the enclosure 402. The blade connectors 404, 405, 406, 407, 408, 409, 410 are designed to support high voltage and high current operation consistent with a single PV module output power. Recessed mounting holes 403, 420, 421 are used in conjunction with a mounting clip to secure the inverter in the mounting bracket using a single installation motion. The dimensions and aspect ratio of the inverter 422 may be adjusted to support differing power requirements based on PV module design. The inverter is lightweight—generally less than 16 ounces—and does not significantly load the PV module to which it is attached.

[0039] FIG. 5 shows, according to another embodiment of the present invention, a mechanical drawing of a side 505 and top view 510 of an inverter mounting bracket mounted on the back of a PV module 502. The bracket is attached to the back of a PV module 502 by an adhesive 509 that is placed between bracket 505 and PV module 502 prior to assembly. The

bracket 505 is molded from a non-conductive material, such as a composite plastic or the like, to minimize cost. Mounting clips 503, 511, 512 are used to lock the inverter in place once the inverter is inserted into the electrical high-voltage receptacles 520, 521, 522, 523, 524, 525 of the bracket 505. DC wiring connections 507 from the inverter receptacles to the PV module are made by wire or bus-bar means. Connectors 504, 530, 531 are used to make all AC connections to the inverter via wires 506 to the inverter receptacles. The connectors 504 can be discrete or can be molded into the body of bracket 505. Inverter receptacles 520, 521, 522, 523, 524, 525 may be recessed into the bracket to improve protection against weather, sunlight, ultraviolet radiation and other environmental features.

[0040] FIG. 6 shows a side and top view of an inverter 602 inserted into an inverter mounting bracket 604 according to an embodiment of the present invention. The high voltage pins 620, 621, 622, 623, 624, 625 of the inverter are inserted into the bracket 604 receptacles. The inverter is locked into place to eliminate disengagement via vibration or accidental means via locking clips 612, 615 that engage inverter mounting holes 613, 614. The design of the inverter 602 and inverter mounting bracket 604 results in spacing 603 of the inverter 602 from the back surface of PV module 605 thereby reducing heating of PV module 605 by heat generated in the inverter 602. It is well known that the conversion of DC power to AC power by an inverter produces as a by product, heat. In a centralized type of system configuration in which DC power transported away from the PV modules for conversion, heat production by the inverter is of little concern. However in system in which an inverter is coupled to each PV module the generation of heat can significantly reduce the efficiency of each photovoltaic cell. To better understand the implications of heat generated by an inverter consider how a PV module operates.

[0041] PV modules operate as current sources derived from a photoexcited semiconductor junction. The maximum available power from the PV cell is defined by the product of its output voltage and current. The current is due to generated photocarriers and, at low output voltages, will be proportional to the incident illumination on the PV cell and is termed the photocurrent. The PV cell behaves as if it has a photocurrent source in parallel with a non-illuminated junction diode. The output voltage is defined by the diode circuit effects implicit in the semiconductor junction and ultimately limits the maximum useful output voltage to a point where the diode current begins to increase significantly. Diode current is a strong function of operating temperature and results in a reduced PV cell voltage for a given output current as temperature rises. PV module output power therefore decreases with temperature. This effect requires that the PV module temperature be kept as low as possible by mitigating any related heat sources as much as possible.

[0042] Previous designs neglect to consider this important aspect of power production. According to one embodiment of the present invention, a replaceable inverter 602 is mounted physically apart from the PV module. By maximizing surface area of the inverter open to surrounding air currents the heat produced by each inverter can be dissipated away from the inverter by way of convection to the atmosphere and not to the PV module.

[0043] No tools are required to insert the inverter and only a simple blade screwdriver is required to release the clips for removal and replacement.

[0044] Shown in FIG. 7 is a mechanical drawing, according to another embodiment of the present invention, of a side 703 and top view 710 of an inverter mounting bracket capable of being mounted on the back of a PV module 702. The bracket is identical in design to the embodiment shown in FIG. 5 with the exception of the method of AC connections. AC connections shown in FIG. 7 are made using multi-conductor cables 704, 730, 731 that are affixed to mounting bracket 710. The cables 704, 730, 731 are directly connected via internal wires 706 to bracket inverter receptacles 720, 721, 722, 723, 724, 725.

[0045] FIG. 8 shows another embodiment of an inverter mounting bracket that can be mounted on the back of a PV module 802. The first AC connection shown in FIG. 8 is made using multi-conductor cable, 804 or 831, that is affixed to the mounting bracket 810. A cable 831 is directly connected via internal wires 806 to bracket inverter receptacles 820, 821, 822, 823, 824, 825. The second AC connection is made via the bracket 810 mounted connector 830 and is connected to the inverter receptacles 820, 821, 822, 823, 824, 825 via additional wiring 806. The connector 830 may be discrete or molded into the body of bracket 810.

[0046] FIG. 9 is a layout drawing, according to one embodiment of the present invention, showing the backside of an array 901 of PV modules 902, 912, 922 with inverter mounting brackets 904, 914, 924 attached at the DC connection location of each module. Inverters 903, 913, 923 are inserted into inverter mounting brackets 904, 914, 924, respectively. Multi-wire AC connecting cables 915, 925 are shown connecting the inverters. A multi-wire AC connecting cable 905 is shown connecting the inverters on the PV modules in the drawing and the AC grid (not shown).

[0047] FIG. 10 is also a layout drawing, according to another embodiment of the present invention, showing the backside of an array 1001 of PV modules 1002, 1012, 1022 with inverter mounting brackets 1004, 1014, 1024 attached at the DC connection location on PV modules 1002, 1012, 1022. The inverters 1003, 1013, 1023, according to the embodiment shown in FIG. 7, are inserted into inverter mounting brackets 1004, 1014, 1024, respectively. Multi-wire AC connecting cables 1006, 1015 are connected together via connectors at the end of each bracket affixed cable. Additional multi-wire AC connecting cables 1016, 1025, 1026, 1035 are connected together via connectors at the end of each bracket affixed cable. The assembly is thereafter connected to the AC grid.

[0048] FIG. 11 shows a mechanical drawing of a top view of an inverter mounting bracket 1110 capable of being mounted on the back of a PV module. Bracket 1110 is similar in design to the embodiment shown in FIG. 7 with the exception of the design of the DC connections. In this embodiment, the DC connections are made using single-wire cables 1111, 1112 that are affixed to mounting bracket 1110. Cables 1111, 1112 are directly connected via their internal wires to bracket inverter receptacles 1120, 1121, 1122, 1123, 1124, 1125. The DC cables 1111, 1112 may be placed in other locations than those shown in FIG. 11.

[0049] Likewise, FIG. 12 presents a layout drawing showing the backside 1214 of a PV module 1212 with inverter mounting bracket 1203 attached according to one embodiment of the present invention. An inverter 1202 is shown inserted into the top of inverter mounting bracket 1203. AC cables 1210, 1211 are shown leaving the bottom of bracket 1203. Single-wire DC cables 1206, 1207 connect the junction box 1205 to the inverter mounting bracket 1203. This allows

the inverter to be used with existing manufactured PV modules 1212 that have junction boxes 1205 pre-assembled without any modifications to PV modules 1212.

[0050] According to another embodiment of the present invention and as shown in FIG. 13, a bracket 1302 is attached to the back of PV module 1303 by an adhesive 1308 that is placed between bracket 1302 and PV module 1303. The bracket 1302 is molded from a non-conductive material, such as a composite plastic or the like, to minimize cost. The inverter 1304 is completely enclosed within bracket 1302. Inverter connections 1320, 1321, 1322, 1323, 1324, 1325 are connected to AC connectors 1306, 1330, 1331 and the PV module by internal wiring. Cables 730, 731 of the inverter mounting bracket 710 shown in FIG. 7 may be substituted for the connectors 1306, 1330, 1331 shown in FIG. 13. Likewise, the cable of the inverter mounting bracket 810 shown in FIG. 8 may be substituted for the connector 1331 shown in FIG. 13.

[0051] FIG. 14 is a mechanical drawing according to another embodiment of the present invention showing a top view of an inverter mounting bracket 1410 mounted on the back of a PV module. The bracket 1410 is identical in design to the embodiment of FIG. 5 with the exception of the method of placement of the inverter connection receptacles. An inverter connection receptacle 1425 is shown partially recessed into the bracket. When the inverter is removed from the bracket 1410, the associated connector pin on the inverter is disconnected from receptacle 1410 prior to the inverter pins connected to receptacles 1420, 1421, 1422, 1423, 1424 being disengaged. A detection circuit is implemented in the inverter to determine that the connection to the receptacle 1410 has been broken and thereby disables all power currents into and out of the inverter. As a result, no arc is formed at the receptacles 1420, 1421, 1422, 1423, 1424 when the inverter is removed. Similarly, power current flow into and out of the inverter is not enabled until after a complete connection has been made on the receptacle 1425 after the power connections have been established on receiving receptacles 1420, 1421, 1422, 1423, 1424. Since the connections have been established prior to the enabling of current, no arc can occur at the connection 1420, 1421, 1422, 1423, 1424. The recessed receptacle 1410 and associated detection circuitry implements a hot-swap function in which the inverter can be removed and replaced while voltages remain active on all the AC and DC connections to the inverter without creating a potentially hazardous arc.

[0052] Similarly the connector pin 425 upon replacement of the inverter prevents operations of the inverter prior to the connection of the receptacles 1420, 1421, 1422, 1423, 1424. As the inverter is mated with the inverter bracket, each receptacle of the inverter mates with a corresponding connection of the inverter bracket. Subsequent to the connections being made the connection pin 1425 establishes contact with a corresponding component of the inverter bracket signifying that operation of the inverter can safely begin. In one embodiment the connection pin is a recessed pin/receptacle combination over which a simple continuity circuit can be attached while in another the pin is a telescoping pin coupled to a switch that signifies whether a complete connection or extraction of the inverter.

[0053] FIG. 15 is a flowchart illustrating methods of implementing an exemplary process for replacing a PV inverter associated with a PV module. In the following description, it will be understood that some blocks of the flowchart illustration, and combinations of blocks in the flowchart illustration,

tions, can be implemented by computer program instructions while other blocks represent physical methodology. When implemented by a computer, these computer program instructions may be loaded onto a computer or other programmable apparatus to produce a machine such that the instructions that execute on the computer or other programmable apparatus create means for implementing the functions specified in the flowchart block or blocks. These computer program instructions may also be stored in a computer-readable memory that can direct a computer or other programmable apparatus to function in a particular manner such that the instructions stored in the computer-readable memory produce an article of manufacture including instruction means that implement the function specified in the flowchart block or blocks. The computer program instructions may also be loaded onto a computer or other programmable apparatus to cause a series of operational steps to be performed in the computer or on the other programmable apparatus to produce a computer implemented process such that the instructions that execute on the computer or other programmable apparatus provide steps for implementing the functions specified in the flowchart block or blocks.

[0054] Accordingly, blocks of the flowchart illustrations support combinations of means for performing the specified functions and combinations of steps for performing the specified functions. It will also be understood that each block of the flowchart illustrations, and combinations of blocks in the flowchart illustrations, can be implemented by various means including a computer, robotics, or via human implementation. Indeed many of the steps illustrated in FIG. 15 can comprise multiple steps that are not listed herein as they would be well known to one skilled in the art. Furthermore the steps listed and discussed below are one example of a process for replacing a PV inverter associated with a PV module according to the present invention.

[0055] FIG. 15 begins **1505** with the identification **1510** of a PV inverter in need of replacement. The identification of an inverter can be due to failure of the inverter, periodic or preventive maintenance or for other reasons known to one skilled in the art. The determination of what PV inverter in a PV system needs to be replaced is not trivial and is not the subject of this invention. Upon identification **1510** the PV inverter is released **1520** from its mounting bracket. Upon release of any physical restraints holding the PV to the inverter bracket the PV inverter can be extracted **1530** from the bracket. Note that during this process, and according to one embodiment of the present invention, the PV system remains operational and indeed the PV module to which the PV inverter is associated continues to provide DC power to the PV inverter.

[0056] As the PV inverter is removed from the inverter bracket but prior to the connectors mating the PV module to the PV inverter from breaking contact, a connector pin indicates **1540** to the inverter that a secure connection between the inverter bracket and the PV inverter has been compromised. Responsive to the connector pin breaking contact, the PV inverter ceases operation **1550**. As one skilled in art will recognize the termination of operation of the PV inverter can be accomplished by a number of methodologies. According to one embodiment a detection circuit is included in the PV inverter to ensure that a positive connection exists between the PV module (inverter bracket) and the PV inverter prior to converting the DC power to AC power. The process ends **1595**

with the inverter being safely removed **1560** from an operation PV module without any electrical arc or danger to the technician.

[0057] While there have been described above the principles of the present invention in conjunction with a PV module AC inverter mount and interconnect, it is to be clearly understood that the foregoing description is made only by way of example and not as a limitation to the scope of the invention. Particularly, it is recognized that the teachings of the foregoing disclosure will suggest other modifications to those persons skilled in the relevant art. Such modifications may involve other features that are already known per se and which may be used instead of or in addition to features already described herein. Although claims have been formulated in this application to particular combinations of features, it should be understood that the scope of the disclosure herein also includes any novel feature or any novel combination of features disclosed either explicitly or implicitly or any generalization or modification thereof which would be apparent to persons skilled in the relevant art, whether or not such relates to the same invention as presently claimed in any claim and whether or not it mitigates any or all of the same technical problems as confronted by the present invention. The Applicant hereby reserves the right to formulate new claims to such features and/or combinations of such features during the prosecution of the present application or of any further application derived therefrom.

We claim:

1. A system for mounting a photovoltaic power element, the system comprising;
 - a bracket affixed to a photovoltaic module having a plurality of photovoltaic cells wherein the bracket includes a first mounting interface wherein direct current leads from the plurality of photovoltaic cells conveying direct current are coupled to the first mounting interface; and
 - a replaceable power element casing housing the photovoltaic power element having a second mounting interface mated with the first interface such that power conveyed from the plurality of photovoltaic cells is modified by the photovoltaic power element and conveyed back to the bracket via the first and second mounting interface.
2. The system of claim 1 wherein the photovoltaic power element is a direct current conditioner.
3. The system of claim 1 wherein the photovoltaic power element is an inverter
4. The system of claim 3 wherein the first mounting interface is positioned on the bracket such that the replaceable power element casing is suspended apart from the photovoltaic module.
5. The system of claim 3 wherein the replaceable power element casing includes supplemental surface area fixtures to facilitate heat transfer.
6. The system of claim 3 wherein the first mounting interface and the second mounting interface include a plurality of interconnects.
7. The system of claim 6 wherein a subset of the plurality of interconnects convey direct current from the bracket to the photovoltaic inverter.
8. The system of claim 6 wherein a subset of the plurality of interconnects convey alternating current from the photovoltaic power element to the bracket.
9. The system of claim 3 wherein replacement of the photovoltaic power element occurs during continuous operation of the photovoltaic module.

10. The system of claim **3** wherein the photovoltaic power element converts direct current of the plurality of photovoltaic cells into three-phase alternating current.

11. The system of claim **3** wherein the photovoltaic power element converts direct current of the plurality of photovoltaic cells into single-phase alternating current.

12. The system of claim **1** wherein the first and second mounting interface masks any electrical arc during replacement of the replaceable power element casing.

13. The system of claim **1** wherein the bracket includes connections capable of linking in parallel the photovoltaic module with other brackets of other photovoltaic modules.

14. The system of claim **1** wherein mating of the first mounting interface to the second mounting interface creates a substantially weather tight seal.

15. A mounting fixture for attaching a photovoltaic power element to a bracket fixed to a photovoltaic module, the mounting fixture comprising;

a first interface housed in the bracket and coupled to direct current leads from photovoltaic cells of the photovoltaic module and to multi-wire cables linking the photovoltaic module to other photovoltaic modules; and

a second interface housed in a replaceable photovoltaic power element casing and coupled to the photovoltaic power element configured to mate with the first interface so as to mount the photovoltaic inverter to the bracket.

16. The mounting fixture of claim **15** wherein the bracket is affixed to the photovoltaic module.

17. The mounting fixture of claim **15** wherein the photovoltaic power element casing includes supplemental surface area fixtures to facilitate heat transfer.

18. The mounting fixture of claim **15** wherein the photovoltaic power element casing is suspended apart from the photovoltaic module.

19. The mounting fixture of claim **15** wherein the replaceable photovoltaic power element is an inverter.

20. The mounting fixture of claim **19** wherein replacement of the replaceable photovoltaic power element occurs during continuous operation of the photovoltaic module.

21. A method for removing a photovoltaic power element in a photovoltaic system, the method comprising;

identifying from among a plurality of operational photovoltaic modules within the photovoltaic system at least one photovoltaic module having a power element bracket wherein the bracket includes a mounting interface coupling the photovoltaic power element to the power element bracket and herein the mounting interface includes a plurality of connectors for conveyance of electrical power between the photovoltaic module and the photovoltaic power element;

releasing the photovoltaic power element from the power element bracket; and

extracting the photovoltaic power element from the power element bracket wherein prior to the plurality of connectors breaking contact, a connector pin connection is broken, and responsive to the connector pin connection being broken the photovoltaic power element ceases operation.

22. The method of claim **21** wherein the photovoltaic power element is an inverter.

23. The method of claim **22** wherein power production of each photovoltaic module within photovoltaic system produces continual power during the extraction of the photovoltaic power element including at the at least one photovoltaic module.

24. The method of claim **22** further comprising replacing the photovoltaic power element with another photovoltaic power element during continuous operation of the at least one photovoltaic module wherein the another photovoltaic power element begins operation subsequent to the connector pin being connected subsequent to the plurality of connectors interfacing the power element bracket to the photovoltaic power element mating.

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