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OPEN ARCHITECTURE TELEMETRY UNIVERSAL TEST HARNESS

STATEMENT OF GOVERNMENT INTEREST

[0001] The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

CROSS REFERENCE TO OTHER APPLICATIONS

[0002] None.

BACKGROUND OF THE INVENTION

(1) Field of the Invention

[0003] The present invention relates generally to test bed technology and more particularly to platforms for supporting simulation and laboratory-condition evaluation of electrical components, modules, and systems of undersea towed arrays.

(2) Description of the Prior Art

[0004] Towed array systems are used for acoustic sensing within marine environments. Such systems typically comprise multiple segments, referred to herein as modules, that when linked together create an array. Common arrays range in size based upon operational capabilities, and often exceed a total length of several hundred meters. Each module may serve a specific function within the operation of the towed array system. Individual electrical components located within the modules can complete specific tasks as a designated function of the array.

[0005] Development of towed array systems requires significant investment for the integration of electronic hardware. The physical configuration of the towed array and the assembly of the modules present costly challenges for the evaluation of electrical component hardware.

[0006] The length of the modules physically consumes a large amount of laboratory and/or development facility space. Installation of the electrical components with the necessary wire lengths between such components requires a time-intensive process of laying out array component parts and then securing the parts.

[0007] Additionally, electrical and other sensitive hardware components are often encapsulated in a resin or polymer-based material. Such encapsulation complicates the ability to accurately probe a component during testing. Furthermore, the user is usually limited to testing a fully assembled module and, consequently, must make generalized conclusions about operational performance.

[0008] Manufacturing modules and assembling them into an array presents a high degree of fabrication difficulty. More specifically, the array assembly process involves sliding sensitive wires and electronics into a selected hose material (a process known as “booting” or “hosing”) which increases the likelihood of damage.

[0009] To aid in the timely and cost-effective research and development of towed arrays, improved systems, methods, and/or devices are required that facilitate the simulation of a physical towed array structure, while allowing for the interchange of electrical hardware components for performance evaluation.

BRIEF SUMMARY OF THE INVENTION

[0010] Accordingly, it is a primary object and general purpose of the present invention to provide a towed array test harness with a movable cart as a support structure. A system of module stack subassemblies and spool subassemblies mount to the support structure and compress an assembled electrical component array into a form for use in a laboratory or product development facility.

[0011] The test harness uses a system of vertically stacked spools for interconnecting power and data lines between electrical components and/or modules of an array. Onboard spooling subassemblies have a number of spools sufficient to accommodate the length of wire(s) included in a towed array.

The test harness also includes vertically arranged electrical components and/or module docking boards that operably engage those components and/or modules, but do not permanently affix the components or modules to the docking boards so that individual components and/or modules may be taken out of the line of the array. When electrical components of the array under test mount to the docking boards, electrical signals from those electrical components are exchanged along inter-device lengths of array wire taken up on the spools.

[0012] The module stack subassemblies and spool subassemblies are carried by respective module holding boxes that are rotatably tethered to a support structure to position the components and/or modules to be accessible to plugs or jacks of analytical and/or probing devices for testing, and/or to digital computer means for programming or reprogramming. Coupling hardware of the module boxes orients each component and/or module under test for ease of access.

[0013] A universal test harness (UTH) assembly can simulate a towed array undersea test. The universal test harness includes at least one module box subassembly characterized by an electrical mounting subassembly of a docking-board type. The electrical mounting subassembly electrically receives a component under test in which the mounting subassembly includes a spool mounting subassembly of a wire spooling type to windingly receive a wire of the towed array. Spools installed in the spool mounting subassembly may include one or more wire spools, module uplink spools, and/or module downlink spools.

[0014] The universal test harness assembly further includes a module cart subassembly to carry and/or transport one or more module box subassemblies. Each module box subassembly carries a respective module stack subassembly with each oriented on a respective separate horizontal plane with respect to a support frame member of the module cart subassembly.

[0015] Each module box subassembly includes hinge and/or pivot hardware to enable each box to independently rotate and/or swing about a vertical axis of the cart frame. When the module box subassemblies are in a closed position; the cart is in a closed configuration volume which is the nominal overall dimensions of the universal test harness form factor used for transport and storage.

[0016] Any number of module box subassemblies may be swung out into the open position at the same time. Each module box subassembly may be coated with suitable electrical isolating paint to reduce the occurrence of electrical arcing when current is flowing through the array under test.

[0017] A method of manufacturing a universal test harness includes the steps of mechanically tethering one or more module box subassemblies to a module cart subassembly such that each of the module box subassemblies is oriented on a separate vertical plane with respect to a frame member of the module cart, and each module stack subassembly is oriented on a separate horizontal plane with respect to a frame member of the module cart.

[0018] The manufacturing method includes the steps of orienting one or more of the module box subassemblies such that proximate module stack subassemblies are in electrical connection with one another. Once a desired electrical connection is made between two module stack subassemblies, a first module stack subassembly is able to send an electrical signal from an electrical component within that module stack subassembly to a receiving module stack subassembly containing a different electrical component. The module stack subassemblies have uniform electrical connection hardware to enable electrical interconnectivity. The manufacturing method further includes mechanically mounting one or more wire spooling subassemblies, each of which is able to accommodate a length of a wire by rotational winding.

[0019] Methods of using a universal test harness include: spooling the wires independently; attaching the spools to the spool subassembly; plugging the connectors of the wires into the docking boards, and then plugging the electrical components into the dock boards; thereby, completing the electrical path. Typically, a distal end of the array is the locus of a signal sensing device. Electrical devices may be positioned in electrical communication along the length of the array. A proximal end of the array includes an electrical device configured to process collected signals into a signal form that can be electrically transmitted to a recording device, a computing device, and/or an analytical device.

[0020] As a wire of the array is wound by a user onto a spool of the universal test harness; the winding process is controlled to collect the wire portion(s) of the array onto the spools and to leave inter-device wire to enable the user to orient an electrical device of the array, or any of the constituent modules, within a module stack subassembly in a positioning that allows an electrical connection. Once the winding step is completed, any electrical device can be electrically connected to any other member of the array and/or to a recording device, a computing device, or an analytical device. Members of the array are stored as electrical components and/or entire modules within module stack subassemblies, which in turn can be carried and oriented by the module box subassemblies. The user of the UTH can collect data from one or more electrical component(s), download data into an electrical device, download new computer operating instructions, and/or reprogram the electrical device with different and/or additional computer operating instructions.

[0021] These and other objects, features, and advantages of the present invention will become more readily apparent from the attached drawings and the detailed description of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] A more complete understanding of the invention and many of the attendant advantages thereto will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings wherein like reference numerals and symbols designate identical or corresponding parts throughout the several views and wherein:

[0023] FIG. 1 depicts a perspective view of an open architecture telemetry universal test harness (UTH) of the present invention with the view illustrating multiple module stack subassemblies vertically aligned in a closed configuration;

[0024] FIG. 2 depicts an assembled perspective view of the universal test harness shown in FIG. 1 with the view illustrating the multiple module stack subassemblies vertically separated relative to each other in an open position;

[0025] FIG. 3 depicts a perspective view of a module stack subassembly of the present invention;

[0026] FIG. 4 depicts a perspective view of an electrical mounting subassembly of the present invention with a top face of the module stack subassembly shown;

[0027] FIG. 5 depicts a perspective view of a spool mounting subassembly of the present invention with a bottom face of the module stack subassembly shown;

[0028] FIG. 6 depicts a front perspective view of a module box subassembly of the present invention with the view illustrating mounting of the module stack subassembly;

[0029] FIG. 7 depicts a rear perspective view of the module box subassembly with the view illustrating module cooling fans and bulkhead connectors;

[0030] FIG. 8 depicts a front perspective view of the module stack subassembly with the view illustrating the interior of the module stack subassembly after removal of the box lid and viewing glass;

[0031] FIG. 9 depicts an example of a perspective view of a module cart subassembly of the present invention with the view illustrating a first example module stack subassembly in an open position and a second example module stack subassembly in a closed position;

[0032] FIG. 10 depicts a perspective view of the module cart subassembly with the view illustrating a workstation and a power/server rack;

[0033] FIG. 11 depicts a perspective view of a module stack frame subassembly of the present invention with the view illustrating mounting therein of the module box subassembly and module stack subassembly;

[0034] FIG. 12 depicts a perspective bottom view of the module stack frame subassembly with the view illustrating lockdown hardware components; and

[0035] FIG. 13 depicts a top-down view of the module stack subassembly with the view illustrating access apertures for the insertion of instrument probes, plugs, and/or jacks.

DETAILED DESCRIPTION OF THE INVENTION

[0036] The present invention is an open architecture telemetry universal test harness that serves as a test platform for electrical hardware components utilized within towed arrays. Referring now to FIG. 1, an open architecture telemetry universal test harness 100 allows for component, module, and array testing of electrical components within towed arrays. The universal test harness assembly 100 includes three major subassemblies: one or more module stack subassemblies 102, one or more module box subassemblies 104, and a module cart subassembly 106. The figure illustrates a universal test harness 100 having sixteen module stack subassemblies 102 with each distributed to and carried by a respective module box subassembly 104. The universal test harness 100 may be scaled for any size array configuration.

[0037] The universal test harness 100 allows a user to access one or more of the module stack subassemblies 102 due to the ability to rotate individual module stack subassemblies 102 to an open state as illustrated in FIG. 2. In an open configuration, the universal test harness 100 presents multiple module stack subassemblies 102 for active in multiple component or module connection or interface locations. As illustrated in FIG. 1 and FIG. 2, portability to a testing location is enabled by the module cart subassembly 106 with a conventional wheeled configuration.

[0038] Referring now to FIG. 3, FIG. 4, and FIG. 5, an example module stack subassembly 102 can contain full wire lengths for electrical components typical to towed array modules and serves as a mounting to individual electrical components and their respective docking boards. The full wire lengths are not separately illustrated in FIG. 3 nor FIG. 5 for clarity and ease of review, but wire lengths are understood to be present when the universal test harness assembly 100 is loaded with the components and modules of a towed array. Real time testing and performance evaluation of the electrical components within the array occurs within the module stack subassembly 102.

[0039] As shown in FIG. 3, each of the module stack subassemblies 102 are divided into two sections: the top section, an electrical mounting subassembly 302; and the bottom section, a spool mounting subassembly 304. The electrical mounting subassembly 302 is for mounting the electrical hardware components under test to their respective docking boards. The spool mounting subassembly 304 includes spools for physically managing the wires connecting the electrical hardware components.

[0040] With reference to FIG. 4, interchangeability of the electrical components occurs within the electrical mounting subassembly 302. The wires of the array travel from one or more of the spools on the spool mounting subassembly 304 to the electrical mounting subassembly 302 through one or more slotted aperture 400.

[0041] The electrical mounting subassembly 302 includes three primary components: a low level telemetry docking Board 402, a high level telemetry and power distribution docking board 404 and a top mounting plate 406. The docking board 402 receives nine TSNS2-Type components and the docking board 404 receives the first level multiplexer 406.

[0042] Referring now to FIG. 5, the spool mounting subassembly 304 may include twenty-four TSNS2-Type wire spools 502; sixteen sets of spool hardware 504; two module uplink spools 512; one module return power spool 514; two module return power spools 516; sixteen spool shields 518; nine support columns 520; two module downlink spools 522; and one bottom mounting board 530.

[0043] The spool shields 518 are placed between the layers in the spool stacking. The spool shields 518 are thin (for example, approximately 0.125 inches) circular plates comprised of a metal that suitably reduces electromagnetic fields that occur when a wire is coiled. Such resulting electromagnetic fields have the potential to add significant noise, or disrupt signals intended to be carried in the respective wires.

[0044] Referring now to FIG. 6 and FIG. 7, and continuing to refer to FIG. 3, FIG. 4, and FIG. 5, each of some number of the module box subassemblies 104 carry a respective module stack subassembly 102 to simulate a single towed array module. The module box subassembly 104 incorporates a module box base 602, a module box lid 604, a module box viewing glass 606, cooling fans 702, bulkhead connections 704, and various critical hardware components including side locking pins 706 (shown with one pin on each side).

[0045] A suitable electrical isolating paint may be applied to the module box base 602 and/or to the module box lid 604 to reduce the likelihood of electrical arcing occurring during testing. In addition, the module box base 602 can have slots around the vertical faces of the base to aid in airflow for cooling the contained module stack subassembly 102. The module box lid 604 and the module box viewing glass 606 can be removable via thumb screws to allow the user to probe the docking boards, connected electrical components under test, and/or to provide additional cooling.

[0046] The cooling fans 702 cool electrical components via forced convection. Power and signal wires are connected to the module box subassembly 104 via the bulkhead connections 704. Data and signal wires may be connected between each module box subassembly 104 to create the full array.

[0047] FIG. 8 illustrates an alternate view of the module box subassembly 104 without the module box lid 604 and module box viewing glass 606. The module stack subassembly 102 is open to active probing during testing and allows for greater cooling of the electrical components.

[0048] Referring now to FIG. 9 and FIG. 10, and additionally to FIG. 3, FIG. 4, and FIG. 5, the module cart subassembly 106 serves as the mounting and transportation fixture for the module box subassemblies 104 and the module stack subassemblies 102. The module cart subassembly 106 includes a cart subassembly 902 and one or more module box frame subassemblies 904 with each configured to rotate around a support frame 1006 of the module cart subassembly.

[0049] The cart subassembly 902 includes the support frame 1006, a power supply rack 1012, a data server rack 1014, and a workstation 1016 which when joined create the supporting structure for the module box subassemblies 104 and for power supply, amplifier and/or receiver systems. The workstation 1016 can store electrical test equipment when the user is probing the module stack subassemblies 102. The wire path of the universal test harness 100 may comprise a signal and power wire(s) exiting their respective systems in the power supply rack 1012 and the server rack 1014 and passing to each of the respective module stack subassemblies 102 connected via the bulkhead connections 704.

[0050] Referring now to FIG. 11, and still referring to FIG. 3, FIG. 4, FIG. 5, FIG. 9, and FIG. 10, the module box frame subassembly 904 includes a frame 1102, frame locking hardware 1104, and a pillow block/rotational lock 1106. Each frame 1102 is positioned along a vertical structure of the support frame 1006, with each module box subassembly 104 attached to a respective frame via the frame locking hardware 1104. Threaded thumbscrew means on the underside of the module box subassembly 104 secures the subassembly to the frame 1102 to prevent vertical movement. A quick-release pull pin can pass through either side of the frame 1102 and module box subassembly 104 to prevent transverse movement of the frame and the module box subassembly on the horizontal axis.

[0051] Rotation of the frame 1102 occurs around the vertical structure of the support frame 1006 through the pillow block/rotational lock 1106. The user can manually rotate the module box subassembly 104 to the desired location and then utilize the rotation lock 1106 to prevent further rotation. The frames 1102 are positioned on the support frames 1006 through use of one or more shaft collar means and thrust bearings means (not shown).

[0052] The module box frame subassembly 904 includes the module frame 1102 and can be secured with the frame locking hardware 1104 on the sides and bottom of the module frame. Rotational movement is controlled via the pillow block and rotational lock 1104. When attached to the support frame 1006, the lock 1104 can locked into a desired location.

[0053] Referring now to FIG. 12, and referring additionally to FIG 1, FIG. 2, and FIG. 11, an underside view of the module box frame subassembly 904 illustrates the location of frame locking hardware 1204.

[0054] Methods of operation and probing using the universal test harness assembly 100 include a storage configuration and an operational configuration. For example, FIG. 1 illustrates the universal test harness assembly 100 in a closed configuration that for storage, transportation, or environmental testing. In the closed configuration, the module box subassemblies 104 are wired together toward the center of the cart 1002. The user can transport the universal test harness assembly 100 in this compact form to a testing location.

[0055] For example, the universal test harness assembly 100 can be characterized by a set of closed-configuration exterior dimensions that are not greater than a height of the universal test harness (for example, of dimension 77.25 inches), length of the universal test harness (for example, of dimension 75.00 inches), and a width of the universal test harness (for example of dimension 36.00 inches). The dimensions length x, height y, and width z can define the closed configuration volume V according to the formula $V = (x) \times (y) \times (z)$.

[0056] In the closed configuration, the dimensions allow a universal test harness to be powered, pushed, and/or towed into a temperature chamber to be exposed for a selected period of time to a selected temperature. One or more module box subassemblies can be configured to be removed from respective mount points on a module cart subassembly; thereby, allowing their respective module stack assemblies to be moved separately into a temperature chamber. Electronic hardware remaining on the module cart subassembly can be outside the temperature-controlled environment and electrically connected to the detached module stack assemblies via wire pass-throughs in the temperature chamber wall (not shown).

[0057] FIG. 2 shows the universal test harness 100 in an open configuration that is used during testing of module stack subassemblies 102. The user can reconfigure the module stack subassemblies 102, through rotation, to the open configuration to access the desired component, module, and/or array level unit. The figure depicts the module stack subassemblies 102 deployed such than no two adjacent pairs of module stack subassemblies are vertically aligned.

[0058] A single or multiple module box subassemblies 104 can be rotated to reach a required configuration. When the constituent module box subassemblies are swung to their open positions; the open configuration volume dimensions can be relied upon to plan the necessary facility room dimensions. For example, a universal test harness assembly can be characterized by a set of open-configuration exterior dimensions that are not greater than a height, length and width of the universal test harness.

[0059] In FIG. 13, the dashed circles 1302 indicate the areas that a user can probe with respect to the module stack subassemblies 102 and the bulkhead connectors 704. The circles

1302 can be universal to matching pairs of the docking board 402 or the docking board 404.

[0060] To use the universal test harness assembly 100 for testing of single or multiple electrical components in the module stack subassembly 102: the user selects a specified module box subassembly 104; opens the box lid 604, and attaches probe hardware to the electrical component positioned in electrical communication with the docking board 402 or the docking board 404. The user then attaches the probes to the desired measurement instrument, performs electrical safety checkouts, and powers-on the component docking board, module, or array. The user can measure the desired value(s) and then can power off the system.

[0061] To use the universal test harness assembly 100 for testing of single or multiple module box subassemblies 104 within a simulated towed array; a user can choose a specified module box subassembly 104 to probe for performance metrics. The user can attach measurement equipment to the bulkhead connections 704, perform electrical safety checkouts, and power on the module or array to test necessary components. The user then can measure the desired value(s) and power off the appropriate module or array.

[0062] To use the universal test harness assembly 100 for testing of an electrical path within a simulated towed array; a user can choose a specific portion of the assembly to probe for desired performance metrics of interest. The user can attach measurement equipment to the section under test, perform electrical safety checkouts, and power on the system. The user then can measure desired value(s) and can power off the universal test harness assembly 100.

[0063] To use the universal test harness assembly 100 for testing of a data path within a simulated towed array, the user can configure the assembly to match the configuration of a desired towed array. The user can attach receiver and towed array recording equipment (e.g., computer, wiring). The user can power on the universal test harness assembly 100 and record the received data from the components under test.

[0064] Another method of use can include for containment of wire lengths, the spool mounting subassembly 304 is configured to incorporate a pegboard design capable of holding necessary module wire lengths as opposed to wire spools. Additionally, the module box subassemblies 104 can be electrically isolated through application of non-conductive elastomeric mats surrounding specified electrical contact points.

[0065] Furthermore, the wires connecting the module box subassemblies 104 can be enclosed in conduits to prevent entanglement and the module cart subassemblies 106 can incorporate a removable safety shield around the perimeter of the cart to increase user safety during testing and to shield the array and testing equipment from accidental collisions.

[0066] Also, the cart subassemblies 902 can be coated with electrically isolating paint to reduce the possibility of electrical arcing. The module box frame subassemblies 904 can attach to the support frame 1006 to further secure respective module box subassemblies 104 during transit (e.g., a new frame structure is engineered to cantilever beam loading). The module box frame subassemblies 904 can also allow respective module box subassemblies 104 to slide forward along the frame 1102 and allow the user to have greater access during testing.

[0067] As generally described above, advantages of the present invention also include but are not limited to the following:

[0068] 1. The design concept of the invention does not require encapsulating materials (e.g., a polyurethane, an epoxy, or other resins) to protect the electrical hardware during the testing phase; thereby, allowing the user to evaluate individual components during testing to determine real-time performance statistics.

[0069] 2. The design concept of the invention does not require the repeated full-scale construction of modules or an array to test new electrical hardware through multiple iterations of testing, full-scale new constructing, re-testing, and more new constructing.

[0070] 3. The disclosed invention allows for full-scale temperature testing to evaluate performance of electrical components, array modules, and full arrays or operational temperature values.

[0071] 4. The invention allows for the attachment of a receiver and towed array recording hardware to enable full array-level data path testing.

[0072] The foregoing description of the preferred embodiments of the invention has been presented for purposes of illustration and description only. It is not intended to be exhaustive nor to limit the invention to the precise form disclosed; and obviously many modifications and variations are possible in light of the above teaching. Such modifications and variations that may be apparent to a person skilled in the art are intended to be included within the scope of this invention as defined by the accompanying claims.

OPEN ARCHITECTURE TELEMETRY UNIVERSAL TEST HARNESS

ABSTRACT OF THE DISCLOSURE

A movable cart having a support structure to carry a plurality of module stack subassemblies representing an electrical component array compressed into a form factor to fit into a confined facility space. Interconnecting power and data lines are deployed between electrical components and modules carried by the module stack subassemblies, with vertically stacked spools configured to take up the length of wires included in the towed array. Vertically arranged electrical components and module docking boards operably and removably engage array components and modules, enabling disconnection / reconnection of a component / module, engagement of an analytical instrument to a component / module, and interconnection of components / modules. Module box subassemblies that carry the module stack subassemblies are rotatably tethered to a support structure of the cart to orient each component and module under test.

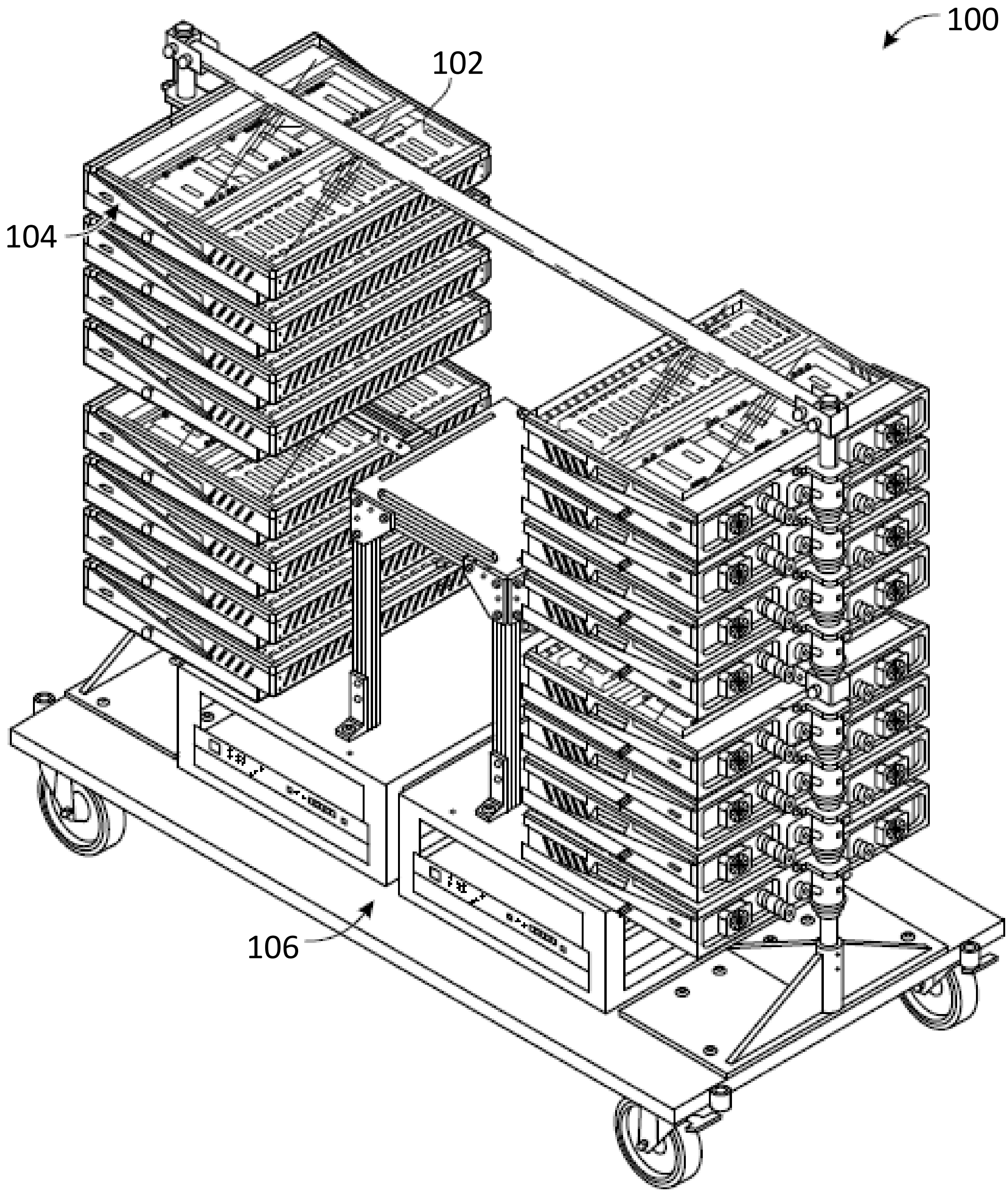

FIG. 1

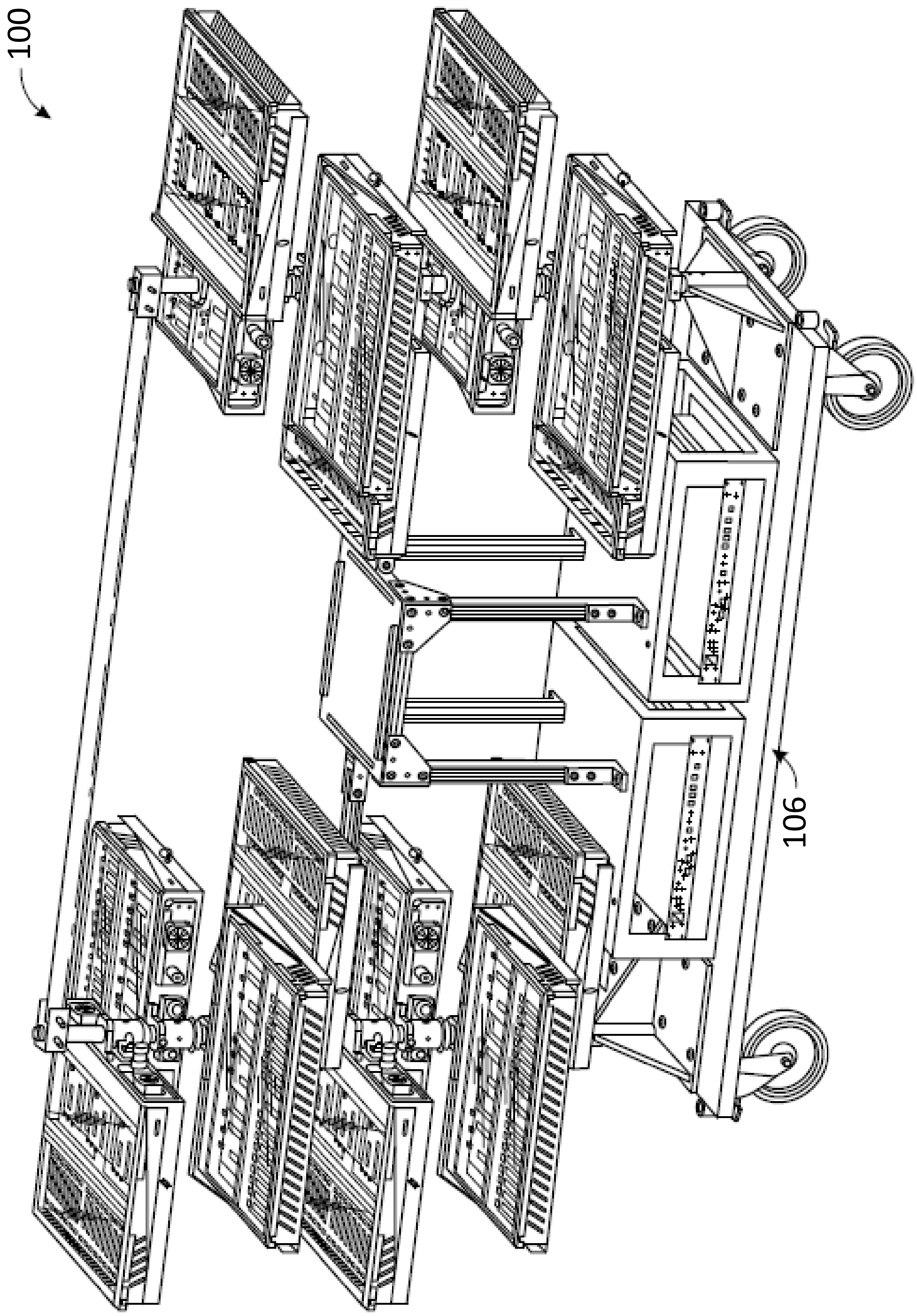

FIG. 2

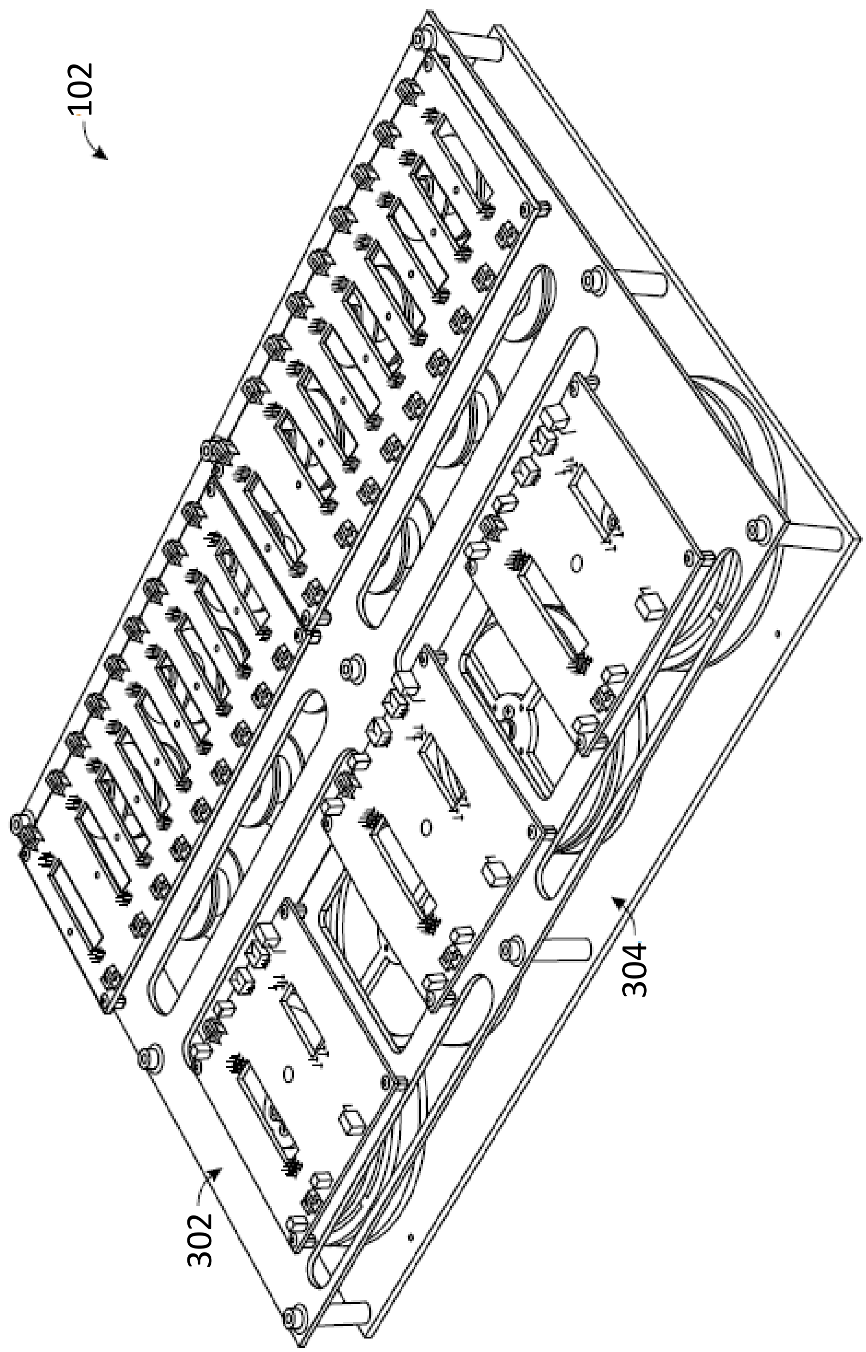

FIG. 3

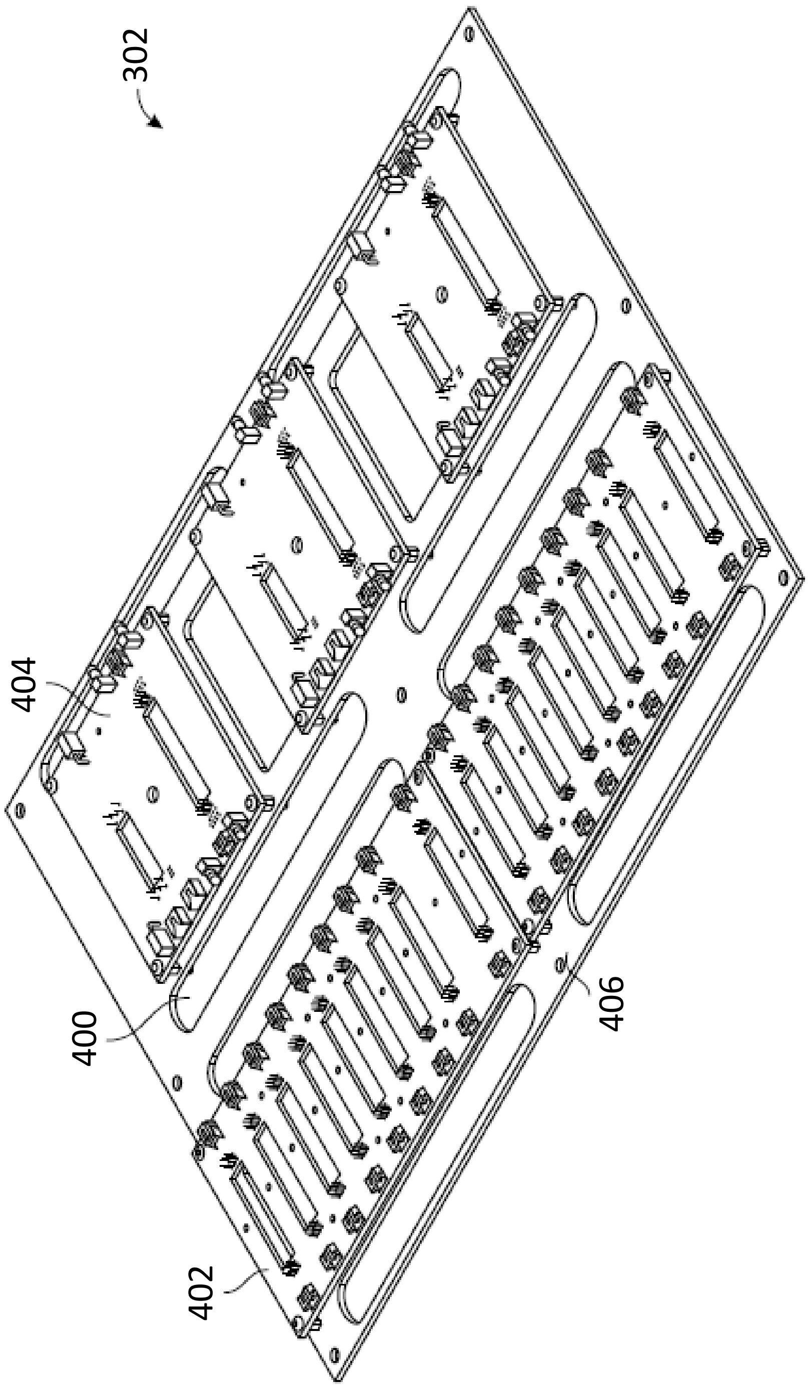

FIG. 4

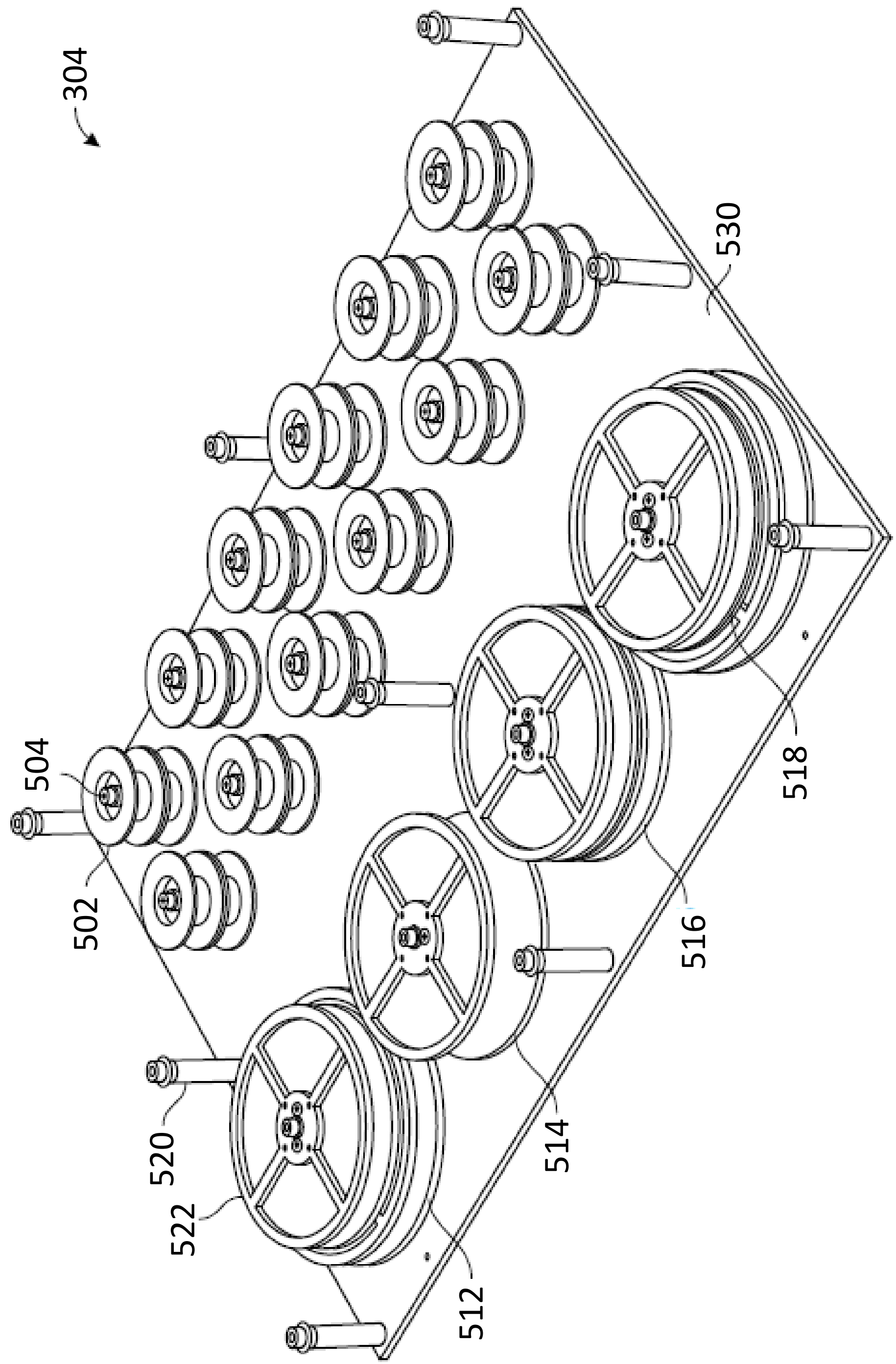

FIG. 5

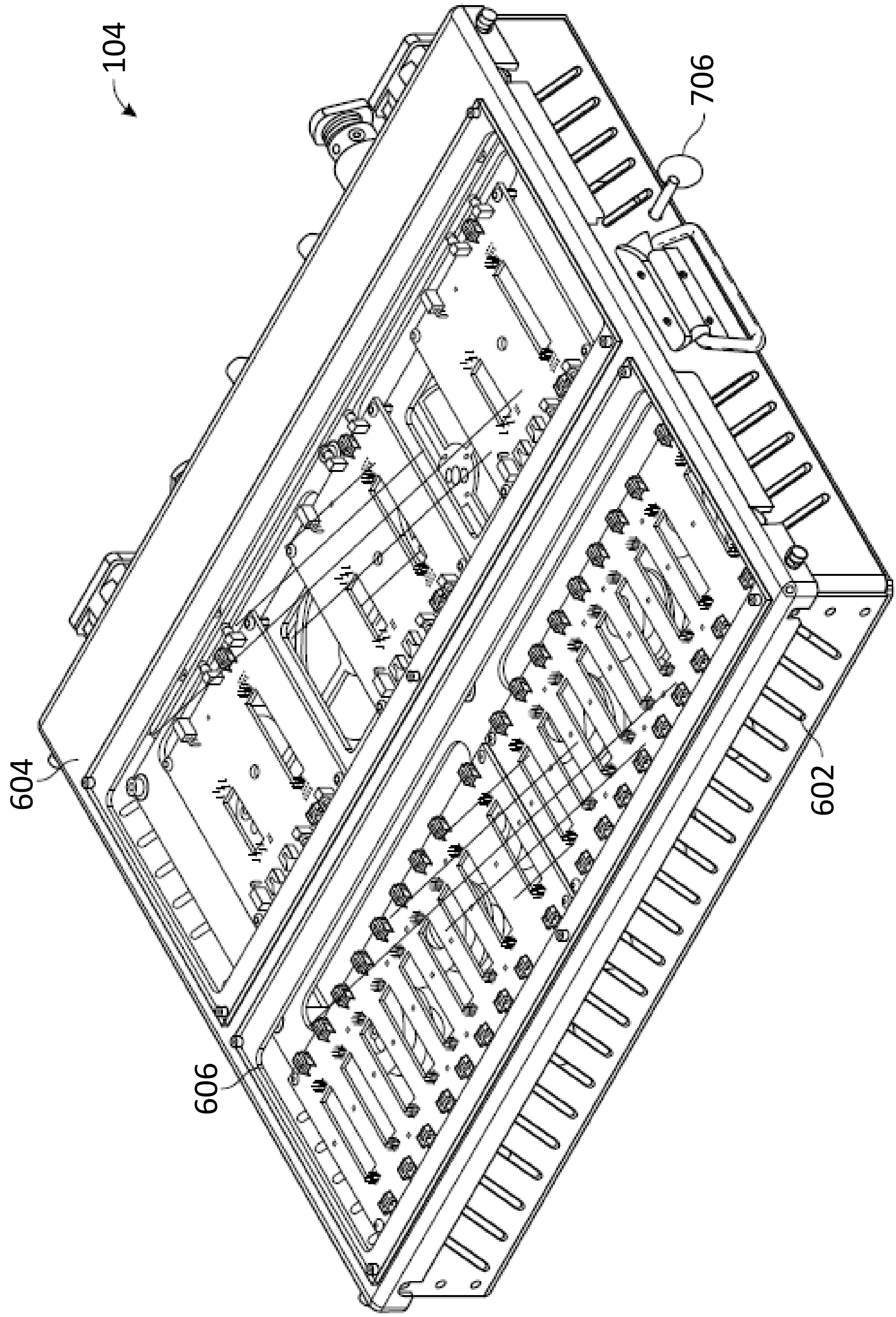

FIG. 6

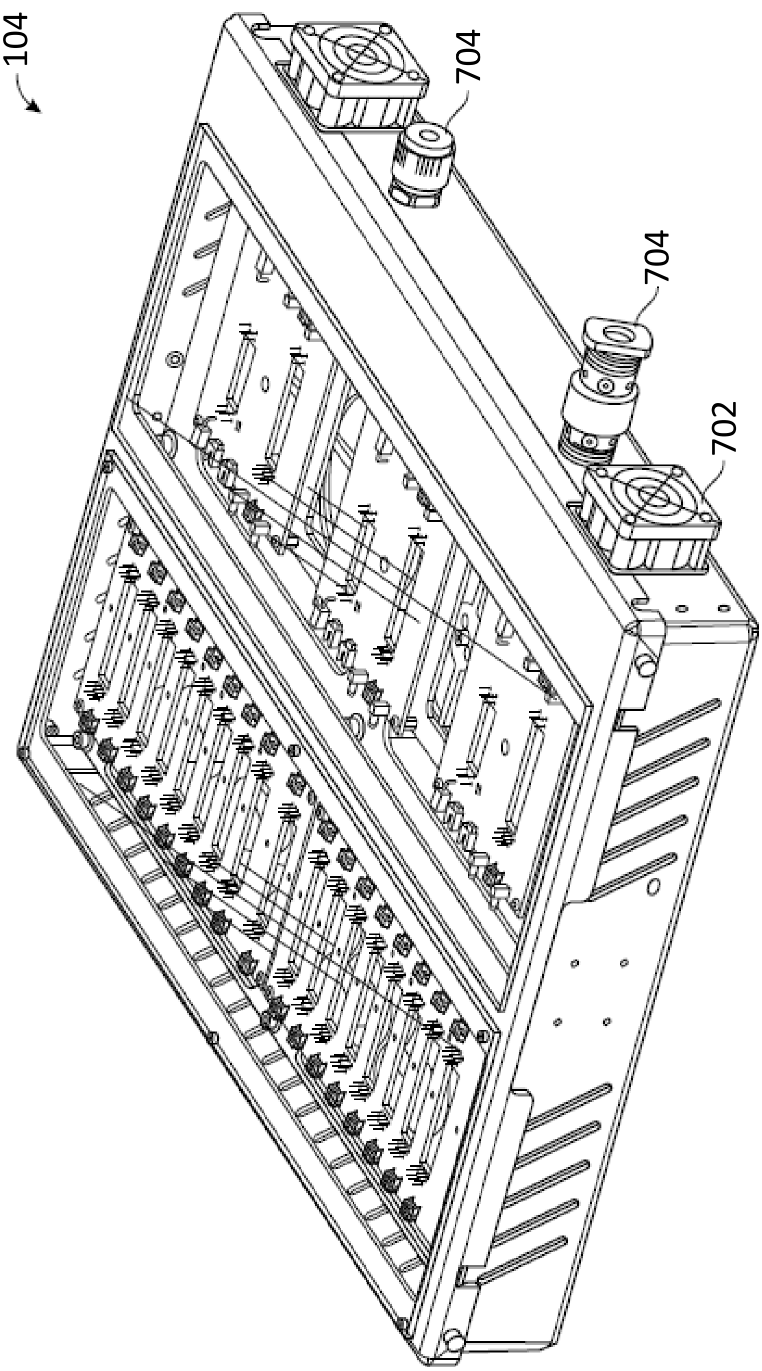

FIG. 7

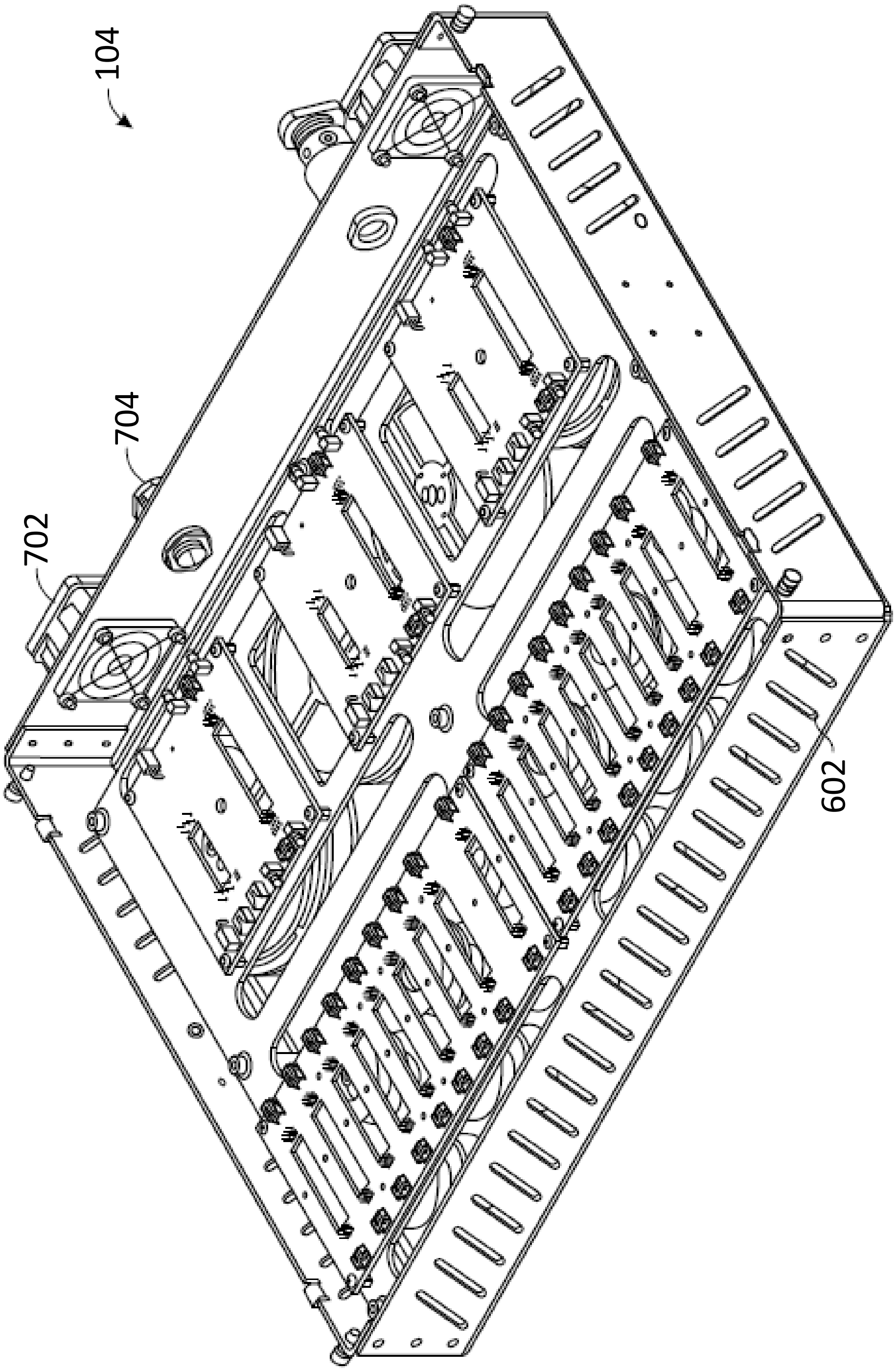

FIG. 8

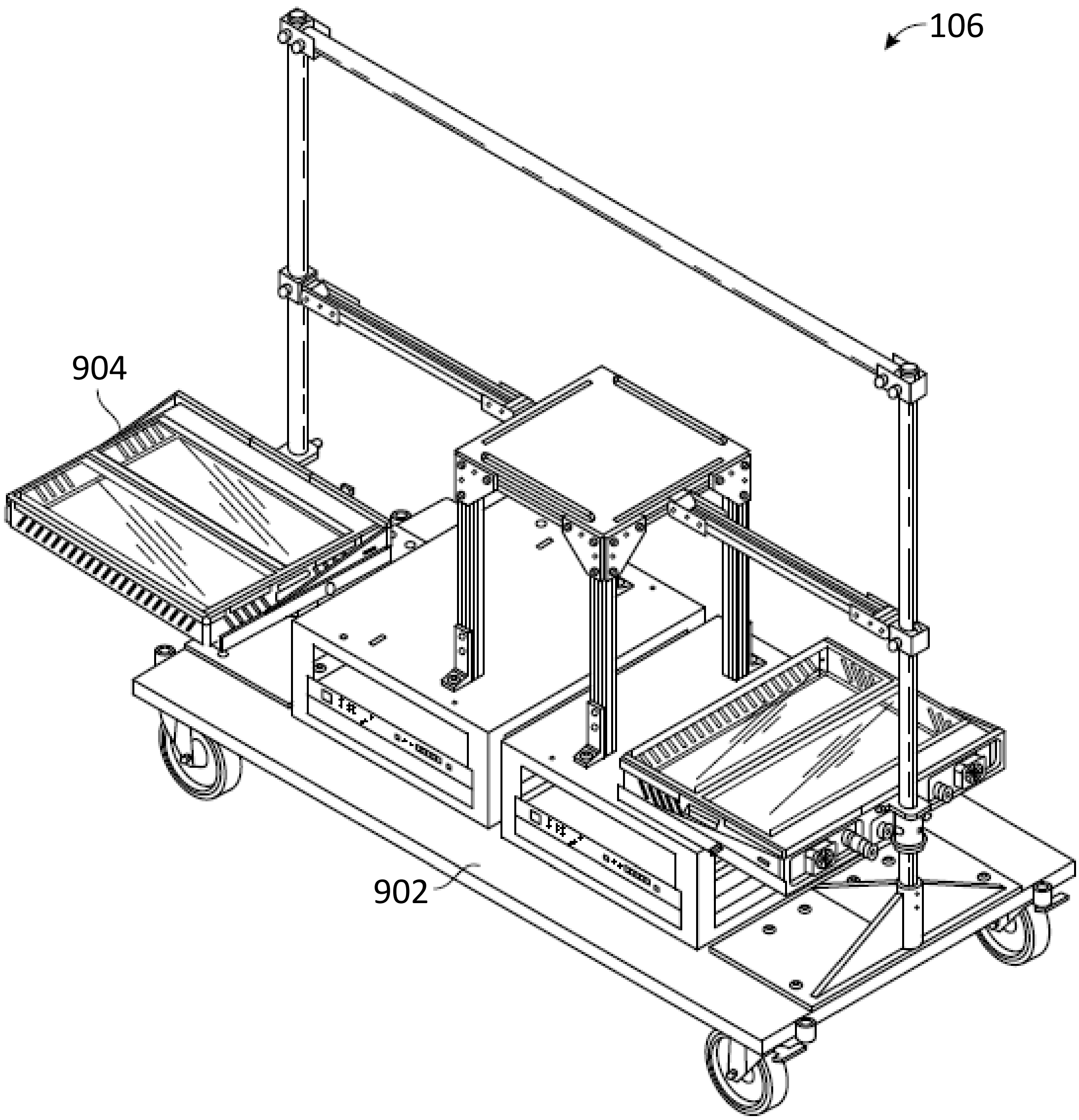

FIG. 9

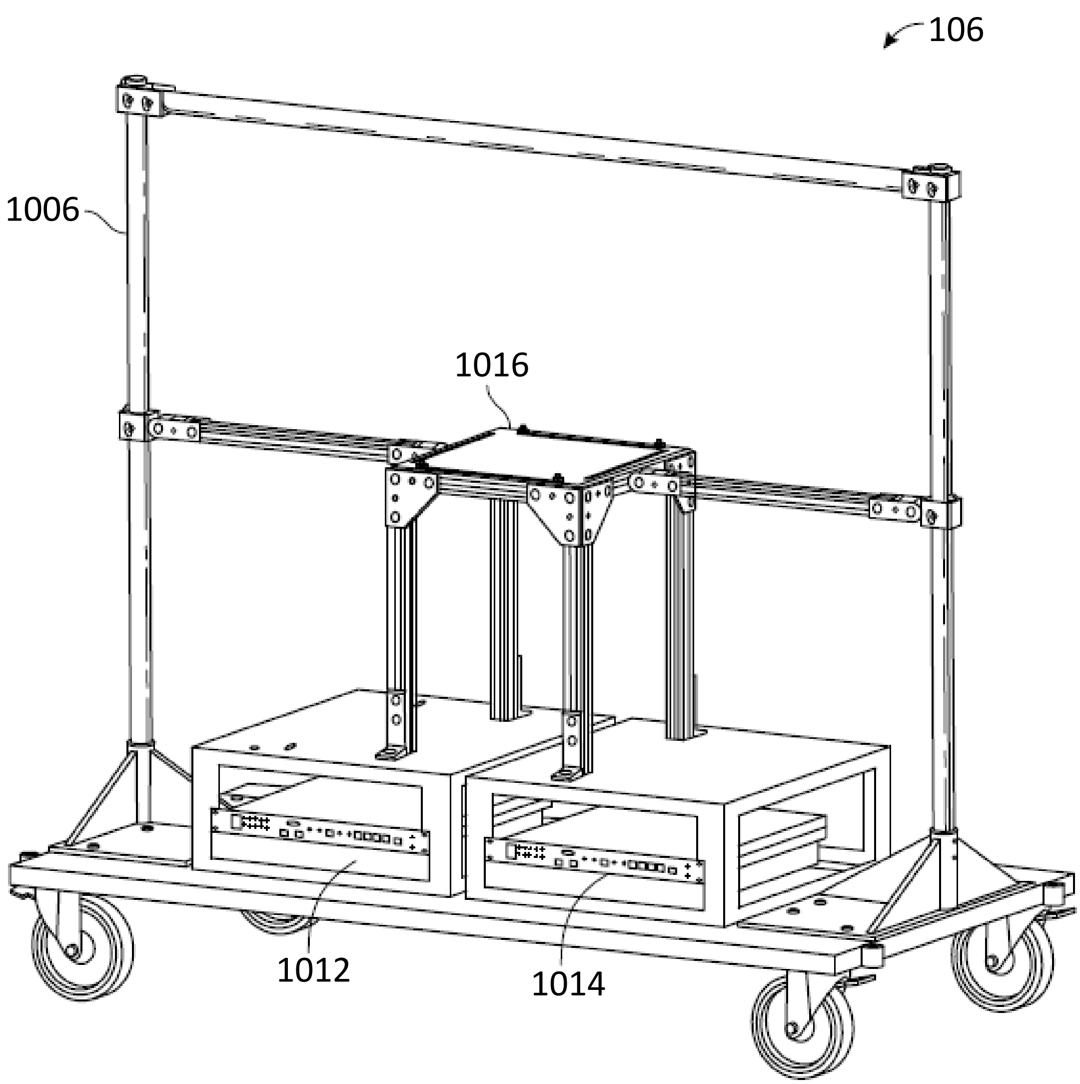

FIG. 10

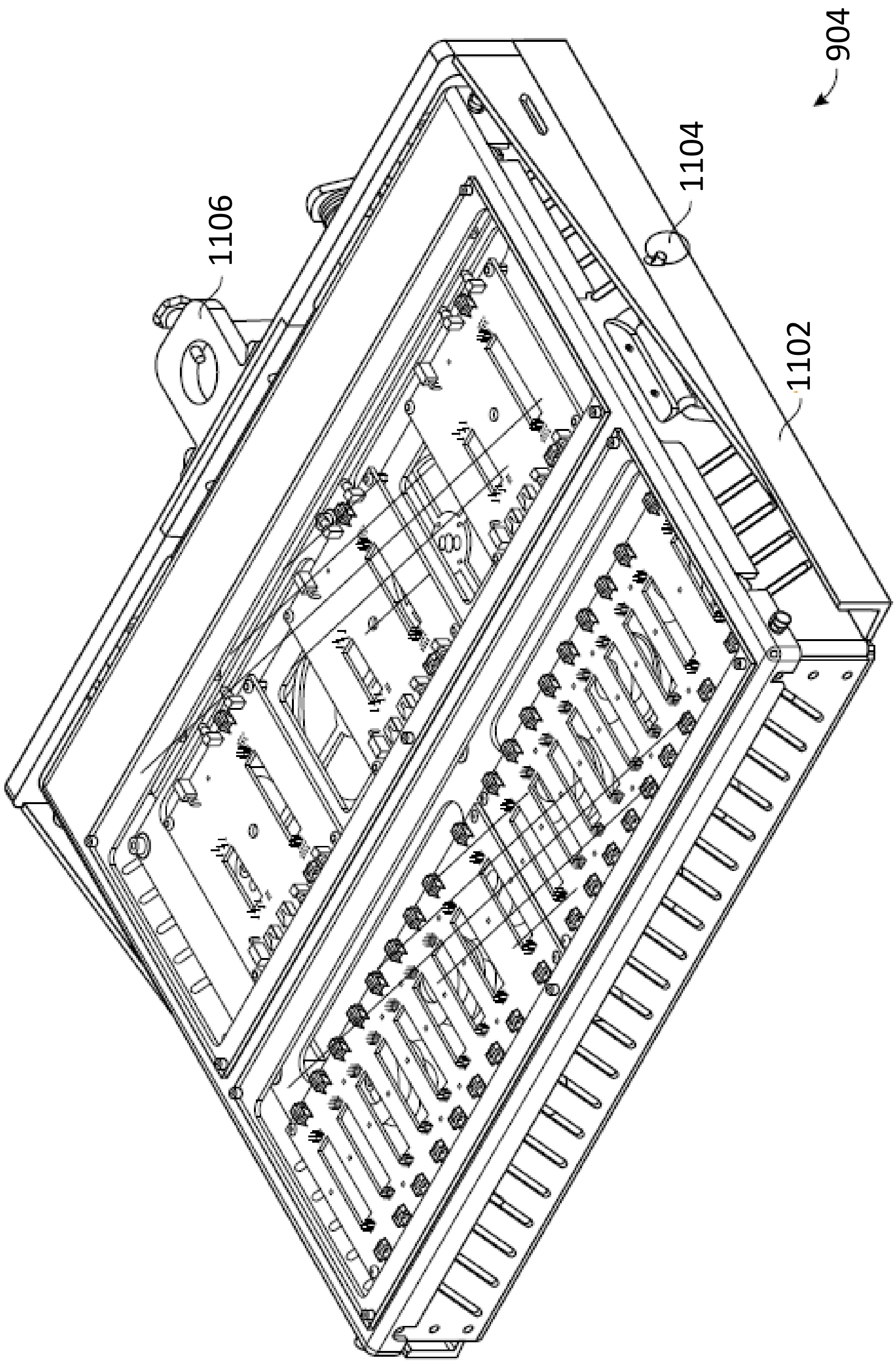

FIG. 11

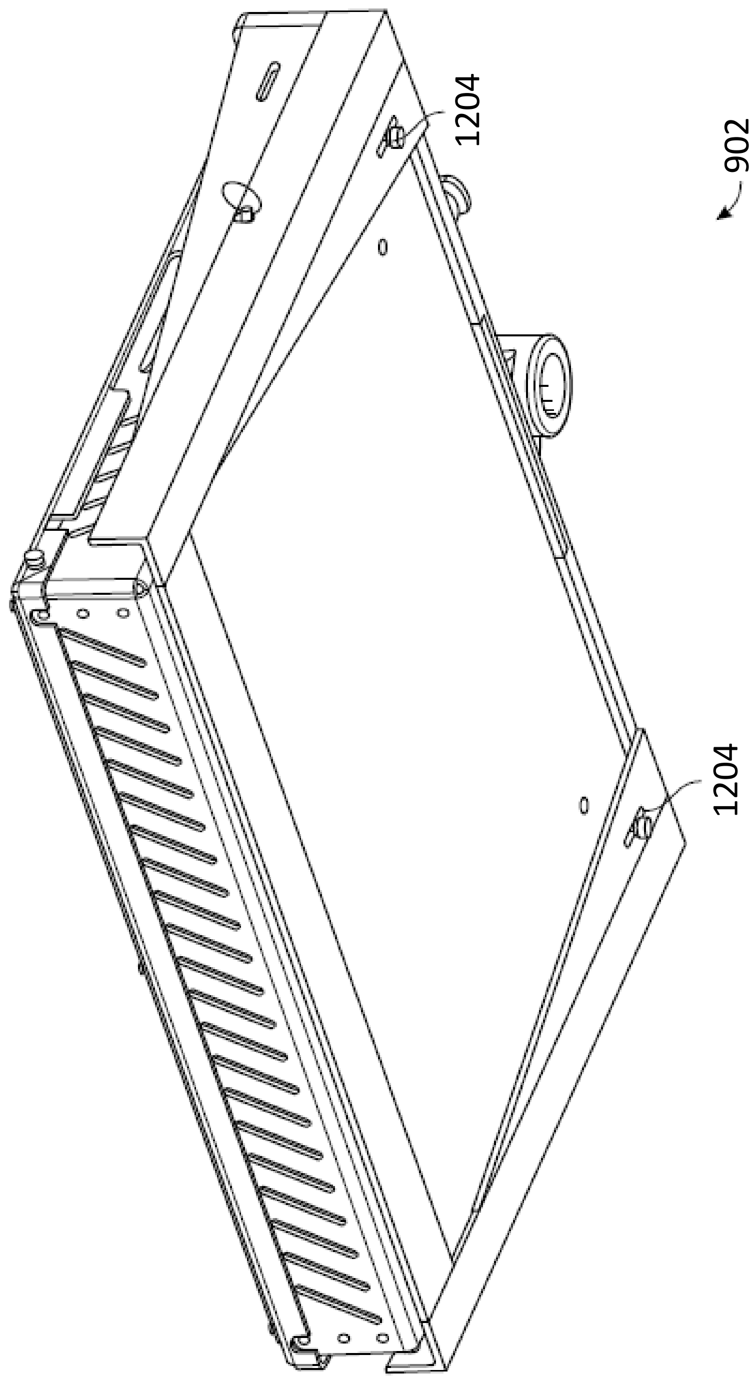

FIG. 12

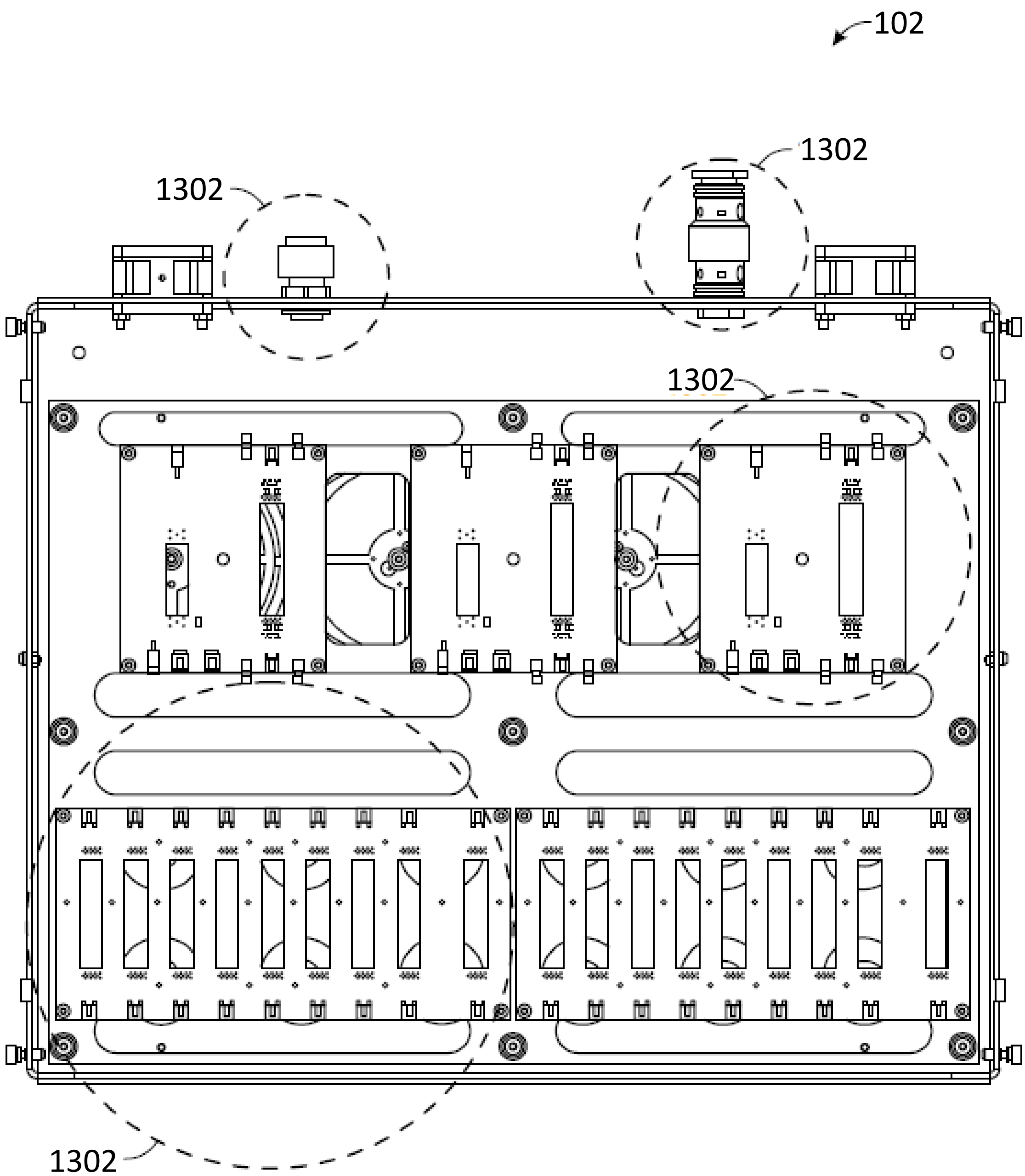

FIG. 13