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(54) **Title:** BATTERY PACK

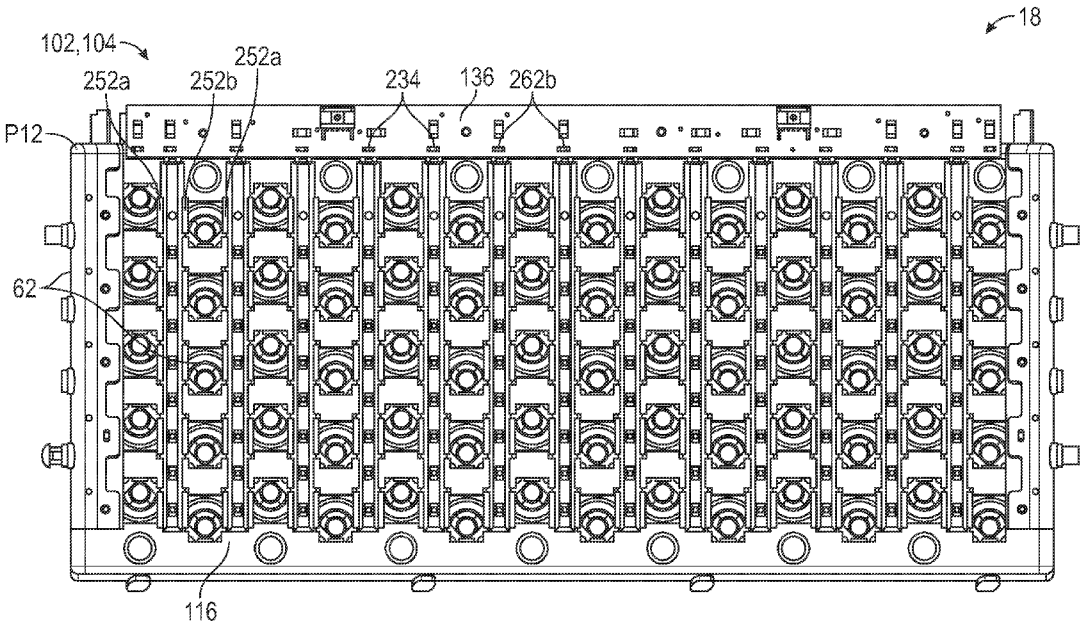


FIG. 29

(57) **Abstract:** A mobile power source that has a battery pack including at least two battery cell assemblies each having frame that has a first support member and a second support member, each of the first and second support members including a plurality of cylindrical recesses that receive the plurality of battery cells to support the battery cells. Bus bars are coupled to the first support member via injection molding and each is configured to electrically connect to at least two battery cells. The bus bars each include an elongated conductive body that has a base and fingers extending laterally away from the base. Each of the fingers extend within a first plane, and the base extends within a second plane that is parallel to the first plane and offset therefrom.

[Continued on next page]

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BATTERY PACK

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Patent Application No. 63/242,816, filed September 10, 2021, and to Chinese Utility Model Application No. 202222315581.0, filed on September 1, 2022, the entire contents of each of which are incorporated by reference herein.

FIELD OF THE DISCLOSURE

[0002] The present disclosure relates to portable power devices such as battery packs.

BACKGROUND OF THE DISCLOSURE

[0003] A portable power device, such as a battery pack, may include a plurality of battery cells.

SUMMARY OF THE DISCLOSURE

[0004] The present disclosure provides, in one aspect, a mobile power source including a battery pack having at least two battery pack assemblies. Each battery cell assembly includes a plurality of battery cells each having a first end, a second end opposite the first end, a positive terminal located at the first end and a negative terminal located at the first end. Each battery cell assembly also includes a frame having a first support member and a second support member, each of the first and second support members including a plurality of cylindrical recesses that receive the plurality of battery cells to support the battery cells. Each battery cell assembly further includes a plurality of bus bars coupled to the first support member and configured to electrically connect to at least two battery cells. Each bus bar includes an elongated conductive body having a base, a plurality of first fingers extending laterally away from the base in a first direction, and a plurality of second fingers extending laterally away from the base in a second direction opposite the first direction. The first fingers and the second fingers extend within a first plane, and the base extends within a second plane that is parallel to the first plane and offset therefrom

[0005] In some constructions, at least two bus bars of the plurality of bus bars are located adjacent one another with the first fingers of each of the at least two bus bars aligned with one another along a direction of a longitudinal axis of the battery pack. In such constructions,

the second fingers of each of the at least two bus bars are aligned with one another along the direction of the longitudinal axis of the battery pack. In some constructions, the first fingers and the second fingers are alternatingly arranged along a longitudinal length of the bus bars. In some constructions, a plurality of wires connects the first fingers of one bus bar to the negative terminals of at least two battery cells and connects the second fingers of the at least one bus bar to the positive terminals.

[0006] The present disclosure provides, in another aspect, a battery pack including at least two battery cell assemblies. Each battery cell assembly includes a plurality of battery cells each having a first end, a second end opposite the first end, a positive terminal located at the first end and a negative terminal located at the first end. Each battery cell assembly also includes a frame having a first support member and a second support member, each of the first and second support members including a plurality of cylindrical recesses that receive the plurality of battery cells to support the battery cells. Each battery cell assembly further includes a plurality of bus bars coupled to the first support member. Each bus bar includes an elongated conductive body having a base, a plurality of first fingers extending laterally away from the base in a first direction, and a plurality of second fingers extending laterally away from the base in a second direction opposite the first direction. Each battery cell assembly also includes a plurality of wires connecting the first fingers of one bus bar to the negative terminals of at least two battery cells and connecting the second fingers of the at least one bus bar to the positive terminals of at least two different battery cells. The first fingers and the second fingers extend within a first plane, and the base extends within a second plane that is parallel to the first plane and offset therefrom.

[0007] The present disclosure provides, in another aspect, a mobile power source comprising a battery pack including at least two battery cell assemblies. Each battery cell assembly includes a plurality of battery cells each having a first end, a second end opposite the first end, a positive terminal located at the first end and a negative terminal located at the first end, a frame having a first support member and a second support member, and bus bars coupled to the first support member via injection molding and configured to electrically connect to at least two battery cells. Each of the first and second support members include a plurality of cylindrical recesses that receive the plurality of battery cells to support the battery cells, and each bus bar includes an elongated conductive body having a base and fingers

extending laterally away from the base. The fingers extend within a first plane, and the base extends within a second plane that is parallel to the first plane and offset therefrom.

[0008] The present disclosure provides, in another aspect, a mobile power source comprising a battery pack including at least two battery cell assemblies. Each battery cell assembly includes a plurality of battery cells each having a first end, a second end opposite the first end, a positive terminal located at the first end and a negative terminal located at the first end, a frame having a first support member and a second support member, and a bus bar positioned within each of the plurality of elongate recesses of the first support member and configured to electrically connect to at least two battery cells. Each of the first and second support members includes a plurality of cylindrical recesses arranged in vertical columns that receive the plurality of battery cells to support the battery cells and elongate recesses. Each of the elongate recesses is positioned adjacent to at least one column of the plurality of cylindrical recesses. Each of the bus bars includes an elongated conductive body having a base and fingers extending laterally away from the base. The base defines a recess. The fingers extend within a first plane and the base extends within a second plane that is parallel to the first plane and offset therefrom. A connection member is positioned within the recess in each base and is integrally formed with the first support member to couple the corresponding bus bar to the first support member. Wires connect the fingers of each the bus bars to either the positive terminal or the negative terminals.

[0009] The present disclosure provides, in another aspect, a method of forming a mobile power supply, the method includes forming a frame having a first support member and a second support member. Each of the first and second support members are formed from a plastic material and include a plurality of cylindrical recesses arranged in vertical columns that receive the plurality of battery cells to support the battery cells and elongate recesses, where each of the elongate recesses is positioned adjacent to at least one column of the plurality of cylindrical recesses. The method further includes positioning a bus bar within one of the elongate recesses of the first support member. Each bus bar includes an elongated conductive body having a base and fingers extending laterally away from the base. The base defines a recess, the fingers extends within a first plane, and the base extends within a second plane that is parallel to the first plane and offset therefrom. The method further includes injecting the recess of each of the bases with the plastic material such that the plastic material fills the recess and integrally forms with the first support member and positioning a plurality

of battery cells between the first support member and the second support member such that the plurality of cylindrical recesses of the first support member and the second support member support the plurality of battery cells. Each of the battery cells have a first end, a second end opposite the first end, a positive terminal located at the first end, and a negative terminal located at the first end. The method also includes wire bonding wires between the fingers each of the bus bars and either the positive terminal or the negative terminals.

[0010] Other aspects of the disclosure will become apparent by consideration of the detailed description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. 1 is a perspective view of a power supply.

[0012] FIG. 2 is a perspective view of a battery pack assembly of the power supply of FIG. 1.

[0013] FIG. 3 is a cross-sectional view of the battery pack assembly of FIG. 2, taken along line 3—3 of FIG. 2.

[0014] FIG. 4 is another cross-sectional view of the battery pack assembly of FIG. 2, taken along line 4—4 of FIG. 2.

[0015] FIG. 5 is another cross-sectional view of the battery pack assembly of FIG. 2, taken along line 5—5 of FIG. 2.

[0016] FIG. 5A is a partially exploded perspective view of the battery pack assembly of FIG. 2 with portions removed.

[0017] FIGS. 6 and 7 are perspective views of the battery pack assembly of FIG. 2 with portions removed.

[0018] FIGS. 8 and 9 are partially exploded perspective views of a battery cell assembly of the battery pack assembly of FIG. 2.

[0019] FIG. 10 is a partial perspective view of a battery cell of the battery pack assembly of FIG. 2.

[0020] FIG. 11 is a partial side view of the battery cell assembly of FIG. 8.

[0021] FIGS. 12 and 13 are partial perspective views of a bus bar of the battery cell assembly of FIG. 10.

[0022] FIG. 14 is an end view of the bus bar of the battery cell assembly of FIG. 8.

[0023] FIG. 15 is a partial cross-sectional view of the battery cell assembly of FIG. 8 according to one embodiment, taken along lines 15—15 of FIG. 11.

[0024] FIG. 16 is a schematic view of two adjacent bus bars according to the embodiment of FIG. 15.

[0025] FIG. 17 is a partial cross-sectional view of the battery cell assembly of FIG. 8 according to another embodiment, taken along lines 15—15 of FIG. 11.

[0026] FIG. 18 is a schematic view of two adjacent bus bars according to the embodiment of FIG. 17.

[0027] FIG. 19 is a partial side view of the battery cell assembly of FIG. 8 according to another embodiment.

[0028] FIG. 20 is a partial side view of the battery cell assembly of FIG. 8 according to another embodiment.

[0029] FIG. 21 is a partial side view of the battery cell assembly of FIG. 8 according to another embodiment.

[0030] FIG. 22 is a partial side view of the battery cell assembly of FIG. 8 according to another embodiment.

[0031] FIG. 23 is a partial side view of the battery cell assembly of FIG. 8 according to another embodiment.

[0032] FIG. 24 is a partial side view of the battery cell assembly of FIG. 8 according to another embodiment.

[0033] FIG. 25 is a partial side view of the battery cell assembly of FIG. 8 according to another embodiment.

[0034] FIG. 26 is a partial side view of the battery cell assembly of FIG. 8 according to another embodiment.

[0035] FIG. 27 is a partial side view of the battery cell assembly of FIG. 8 according to another embodiment.

[0036] FIG. 28 is a partial side perspective view of the battery cell assembly of FIG. 8 according to another embodiment.

[0037] FIG. 29 is a side view of a battery cell assembly of FIG. 8 according to another embodiment, the battery cell assembly including a first support member, a plurality of bus bars, and a voltage sensing PCB.

[0038] FIG. 30 is a perspective side view of a battery cell assembly of FIG. 29 with the voltage sensing PCB removed.

[0039] FIG. 31 is a perspective side view of a battery cell assembly of FIG. 29 with the plurality of bus bars and the voltage sensing PCB removed.

[0040] FIG. 32 is a cross-sectional view of the battery cell assembly of FIG. 29 along the line 32—32 of FIG. 30.

[0041] FIG. 33 is a cross-sectional view of the battery cell assembly of FIG. 29 along the line 33—33 of FIG. 30.

[0042] FIG. 34 is a cross-sectional view of the battery cell assembly of FIG. 29 along the line 34—34 of FIG. 30.

[0043] FIG. 35 is a cross-sectional view of the battery cell assembly of FIG. 29 along the line 35—35 of FIG. 30.

[0044] FIG. 36 is a perspective view of one of the plurality of bus bars of FIG. 29.

[0045] FIG. 37 is another perspective view of the of bus bar of FIG. 36.

[0046] FIG. 38 is a cross-sectional view of the bus bar of FIG. 36 along the line 38—38 of FIG. 36.

[0047] FIG. 39 is a cross-sectional view of the bus bar of FIG. 36 along the line 39—39 of FIG. 36.

[0048] FIG. 40 is a perspective view of one of the plurality of bus bars of FIG. 29.

[0049] FIG. 41 is another perspective view of the of bus bar of FIG. 40.

[0050] FIG. 42 is a detailed perspective view of the bus bar of FIG. 40.

[0051] FIG. 43 is a cross-sectional view of the bus bar of FIG. 40 along the line 43—43 of FIG. 40.

[0052] FIG. 44 is a perspective view of one of the plurality of bus bars of FIG. 29.

[0053] FIG. 45 is another perspective view of the of bus bar of FIG. 44.

[0054] FIG. 46 is a detailed perspective view of the bus bar of FIG. 44.

[0055] FIG. 47 is a cross-sectional view of the bus bar of FIG. 44 along the line 47—47 of FIG. 44.

[0056] Before any embodiments of the disclosure are explained in detail, it is to be understood that the disclosure is not limited in its application to the details of embodiment and the arrangement of components set forth in the following description or illustrated in the following drawings. The disclosure is capable of other embodiments and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting.

DETAILED DESCRIPTION

[0001] FIG. 1 illustrates a portable power supply device or power supply 1. The portable power supply device 1 includes a housing 2. In some embodiments, the power supply 1 includes one or more wheels 3 coupled to the housing 2, and a handle assembly 4 coupled to the housing 2. In the illustrated embodiment, the handle assembly 4 is a telescoping handle movable between an extended position and a collapsed position. The handle assembly 4 includes an inner tube 5 and an outer tube 6. The inner tube 5 fits inside the outer tube 6 and is slidable relative to the outer tube 6. The inner tube 5 is coupled to a horizontal holding

member 7. In some embodiments, the handle assembly 4 further includes a locking mechanism to prevent inner tube 5 from moving relative to the outer tube 6 by accident. The locking mechanism may include notches, sliding catch pins, or another suitable locking mechanism to inhibit the inner tube 5 from sliding relative to the outer tube 6 when the handle assembly 4 is in the extended position and/or in the collapsed position. In practice, a user holds the holding member 7 and pulls upward to extend the handle assembly 4. The inner tube 5 slides relative to the outer tube 6 until the handle assembly 4 locks in the extended position. The user may then pull and direct the power supply 1 by the handle assembly 4 to a desired location. The wheels 3 of the power supply 1 facilitate such movement.

[0002] The housing 2 of power supply 1 further includes a power input panel 8, a power output panel 9, and a display 11. In the illustrated embodiment, the power input panel 8 includes multiple electrical connection interfaces configured to receive power from an external power source. In some embodiments, the external power source may be a DC power source, for example, a photovoltaic cell (e.g., a solar panel), or the power source may be an AC power source, for example, a conventional wall outlet. In some embodiments, the power input panel 8 is replaced by or additionally includes a cable configured to plug into a conventional wall outlet. The power received by power input panel 8 may be used to charge an internal power source 10 disposed within the housing 2 of power supply 1.

[0003] The power output panel 9 includes one more power outlets. In the illustrated embodiment, the power output panel 9 includes a plurality of AC power outlets 9A and DC power outlets 9B. It should be understood that number of power outlets included in power output panel 9 is not limited to the power outlets illustrated in FIG. 1. For example, in some embodiments of the power supply 1, the power output panel 9 may include more or fewer power outlets than the power outlets included in the illustrated embodiment of power supply 1. The power output panel 9 is configured to provide power from the internal power source 10 to one or more peripheral devices. The one or more peripheral devices may be a smartphone, a tablet computer, a laptop computer, a portable music player, a power tool, a power tool battery pack, a power tool battery pack charger, or the like. The peripheral devices may be configured to receive DC and/or AC power from the power output panel 9. In some embodiments, the power supply 1 also includes one or more battery pack charging

receptacles (not shown) configured to receive one ore more battery packs and provide power from the internal power source 10 to the one or more battery packs.

[0057] The display 11 is configured to indicate a state of the power supply 1 to a user, such as state of charge of the internal power source 10 and/or fault conditions. In some embodiments the display 11 includes one or more light-emitting diode ("LED") indicators configured to illuminate and display a current state of charge of internal power source 10. In some embodiments, the display 11 is, for example, a liquid crystal display ("LCD"), a light-emitting diode ("LED") display, an organic LED ("OLED") display, an electroluminescent display ("ELD"), a surface-conduction electron-emitter display ("SED"), a field emission display ("FED"), a thin-film transistor ("TFT") LCD, etc. In other embodiments, the power supply 1 does not include a display.

[0058] FIGS. 2-30 illustrate all or portions of the internal power source 10 according to several different embodiments. Hereafter, the internal power source 10 will be referred to as a battery pack assembly 10.

[0059] With reference to FIG. 2-6, in one embodiment, the battery pack assembly 10 includes a housing 14 and a plurality of battery cell assemblies 18 received within the housing 14. In the illustrated embodiment, the battery pack assembly 10 includes two battery cell assemblies 18. In other embodiments, the battery pack assembly 10 may include one or more battery cell assemblies 18 (e.g., three, four, etc.). The battery pack assembly 10 is configured to be a high power battery pack connectable to and operable to power various motorized power tools (e.g., a cut-off saw, a miter saw, a table saw, a core drill, an auger, a breaker, a demolition hammer, a compactor, a vibrator, a compressor, a drain cleaner, a welder, a cable tugger, a pump, etc.), outdoor tools (e.g., a chain saw, a string trimmer, a hedge trimmer, a blower, a lawn mower, etc.), other motorized devices (e.g., vehicles, utility carts, a material handling cart, etc.), etc. and non-motorized electrical devices (e.g., a power source, a light, an AC/DC adapter, a generator, personal electronic device, etc.), any one of which is now referred to herein as "device."

[0060] The housing 14 includes a top side 22, a bottom side 26, a first lateral side 30, a second lateral side 34 opposite the first lateral side 30, a first end 38, and a second end 42 opposite the first end 38. In addition, the housing 14 includes a longitudinal axis 46 extending through the first end 38 and the second end 42. A lateral axis 50 of the housing 14

extends through the first lateral side 30 and the second lateral side 34. The lateral axis 50 is perpendicular to the longitudinal axis 46.

[0061] With reference to FIGS. 3-5, the housing 14 further includes an internal cavity 58 defined therewithin. Each battery cell assembly 18 is positioned within the internal cavity 58. In addition, the housing 14 is sealed such that the internal cavity 58 is not in fluid communication with an exterior of the battery pack assembly 10. In other embodiments (not shown), the housing 14 can be unsealed.

[0062] With reference to FIGS. 4-7, each battery cell assembly 18 includes a plurality of battery cells 62, a plurality of bus bars 66, and a housing or frame 70 supporting the plurality of battery cells 62 within the internal cavity 58. Each battery cell 62 has a body 74 extending between a first end 78 and a second end 82. In addition, each body 74 extends along a battery cell axis 86 (FIG. 5) that extends through the respective first and second lateral sides 30, 34, respectively of the housing 14.

[0063] A support plate 90 (FIG. 6) is secured to each of the battery cell assemblies 18 at a top side thereof adjacent the top side 22 of the housing 14. In addition, the longitudinal ends of the battery cell assemblies 18 are secured to fan cowls 91a and 91b (FIG. 5A) that are provided adjacent to the first end 38 or the second end 42 of the housing 14, respectively. The fan cowls 91a, 91b can be coupled to the battery cell assemblies 18 before the support plate 90 is secured to the cell assemblies 18 to aid with aligning the support plate 90 with the cell assemblies 18. The fan cowls 91a, 91b receive one or more fans 92 operable to generate an airflow within the internal cavity 58 to provide thermal benefit to the battery pack assembly 10. The battery pack assembly 10 also includes a main printed circuit board (PCB) 94 coupled to the support plate 90. The main PCB 94 supports control circuitry 98 for controlling operation of the battery pack assembly 10.

[0064] Each battery cell assembly 18 is arranged within the internal cavity 58 such that each of the battery cells 62 are oriented relative to the longitudinal axis 46 of the housing 14. In the illustrated embodiment, the battery cell axis 86 of each respective battery cell 62 extends perpendicular to the longitudinal axis 46 (or parallel to the lateral axis 50) within the internal cavity 58. In other embodiments, the battery cell axis 86 may be oriented parallel to the longitudinal axis 46 and/or some of the battery cell axes 86 may be oriented in the same or different directions. In the illustrated embodiment, each battery cell assembly 18 includes

seventy battery cells 62. In other embodiments, the battery cell assembly 18 may include two or more battery cells 62. The housing 14 is shaped and sized to receive a predetermined number of battery cell assemblies 18 in which each battery cell assembly 18 has a portion of the predetermined number of battery cells 62.

[0065] With reference to FIGS. 6-9, the frame 70 of each battery cell assembly 18 includes a first support member 102 and a second support member 104 coupled to the first support member (e.g., via fasteners 112). Each support member 102, 104 defines a plurality of cylindrical recesses 108 corresponding to the battery cells 62. The recesses 108 of the first support member 102 receive the first ends 78 of the battery cells 62 and the recesses 108 of the second support member 104 receive the second ends of the battery cells 62. As such, each support member 102, 104 has the same number of recesses 108 as the number of battery cells 62. The illustrated recesses 108 are arranged in vertical columns (i.e., along a direction perpendicular to both the longitudinal and lateral axes 46, 50). And, the recesses 108 of adjacent vertical columns are staggered relative to one another. Accordingly, the support members 102, 104 locate and maintain a position of each battery cell 62 within the internal cavity 58.

[0066] Within the battery pack assembly 10, the first support member 102 of each battery cell assembly 18 is located adjacent the lateral sides 30 or 34, respectively. The second support members 104 are positioned opposite the first support members 102 and inward relative to the first support members 102 within the internal cavity 58. Each support member 102, 104 of the two battery cell assemblies 18 includes a lateral surface 116 (FIGS. 6 and 7). The lateral surfaces 116 of the second support members 104 are positioned in facing relationship with each other within the internal cavity 58. The lateral surfaces 116 of the first support members 102 face away from one another and support at least a portion of the bus bars 66 of each battery cell assembly 18.

[0067] With reference to FIG. 10, each battery cell 62 includes a positive terminal 120 and a negative terminal 124 that are each located at the first end 78. The positive terminal 120 is located at a central region of the first end 78. The negative terminal 124 is located radially outward from the positive terminal 120. In the illustrated embodiment, the negative terminal 124 is formed as a portion of the canister crimp of the battery cell 62. An insulator or gasket 128 separates the positive terminal 120 from the negative terminal 124 to prevent short circuiting. Each battery cell 62 may have a nominal voltage between about 3 V and

about 5 V and may have a nominal capacity between about 2 Ah and about 6 Ah (in some cases, between about 3 Ah and about 5 Ah). The battery cells 62 may be any rechargeable battery cell chemistry type, such as, for example, lithium (Li), lithium-ion (Li-ion), other lithium-based chemistry, nickel-cadmium (NiCd), nickel-metal hydride (NiMH), etc.

[0068] With reference to FIGS. 6 and 7, the battery cells 62 may be connected in series, parallel, or a combination of series and parallel to provide the desired electrical characteristics (e.g., nominal voltage, current output, current capacity, power capacity, etc.) of the battery pack assembly 10. The battery cells 62 are electrically connected by the bus bars 66. In the illustrated embodiment, the battery cells 62 are connected in a series-parallel arrangement with five groups of the battery cells 62 connected in parallel, and each group having fourteen battery cells 62 connected in series (i.e., a "14s5p" arrangement). The two battery cell assemblies 18 are connected with each other in series along with main positive and negative terminals 126, 127 of the battery pack assembly 10. Accordingly, the battery pack assembly 10 includes, in total, 140 battery cells 62 arranged in five parallel-connected groups of 28 series-connected battery cells 62 (i.e., a "28s5p" battery pack assembly).

[0069] With reference to FIG. 11, the first support member 102 includes a plurality of apertures 132 extending between the lateral surface 116 and a bottom surface of each cylindrical recess 108. The apertures 132 expose the positive and negative terminals 120, 124 of each battery cell 62. The bus bars 66 extend in the vertical direction along the lateral surface 116 and are positioned between each column of the battery cells 62. Each battery cell assembly 18 also includes a voltage sensing PCB 136 supported on the lateral surface 116 of the first support member 102 adjacent the main PCB 94 and adjacent the top side 22 of the housing 14. The voltage sensing PCB 136 may be electrically coupled to the bus bars 66 (e.g., via bonded wires 140 or soldering, as discussed below) and configured to sense voltages of the battery cells 62.

[0070] In the illustrated embodiment, each battery cell 62 is connected by wires 140 to the two adjacent bus bars 66 extending on either side of the battery cell 62 (e.g., by a wire bonding process such as welding). In the illustrated embodiment, from the frame of reference of FIG. 11, the positive terminal 120 of each battery cell 62 is connected by one wire 140 to the adjacent bus bar 66 located to the left of the battery cell 62. Each negative terminal 124 of each battery cell 62 is connected by one wire 140 to the adjacent bus bar 66 located to the right of the battery cell 62. Thus, the positive terminals 120 of the five battery cells 62 of

each vertical column are each connected by wires 140 to the adjacent bus bar 66 located to the left, and the negative terminals 124 of the five battery cells 62 of each vertical column are each connected by wires 140 to the adjacent bus bar 66 located to the right. Each bus bar 66 is coupled to at least two or more battery cells 62. In the illustrated embodiment, each bus bar 66 is coupled to ten battery cells 62 (i.e., to the five negative terminals 124 to the left of the bus bar 66 and to the five positive terminals 120 to the right of the bus bar 66).

[0071] With reference to FIGS. 11-14, each illustrated bus bar 66 is formed as an elongated conductive body 144 having a longitudinal ridge or base 148, a plurality of first fingers 152a protruding laterally outward from a first side of the base 148, and a plurality of second fingers 152b protruding laterally outward from an opposite second side of the base 148. The fingers 152a, 152b are generally equal in width and each project the same lateral distance outward from the base 148. The fingers 152a, 152b are generally flat and each extend within a first plane P1 (FIG. 14). The base 148 is also generally flat and extends within a second plane P2 that is parallel to the first plane P1 and offset therefrom. A first connecting section 156 connects the base 148 to the first fingers 152a and a second connecting section 160 connects the base 148 to the second fingers 152b. The fingers 152a, 152b are misaligned with each other along a longitudinal length of the bus bar 66 and are arranged in a staggered or alternating configuration. In other words, moving along the longitudinal length of the bus bar 66 from a first longitudinal end toward an opposite second longitudinal end, each first finger 152a is followed by a second finger 152b, which is then followed by a subsequent first finger 152a, followed by a subsequent second finger 152b, etc.

[0072] With continued reference to FIG. 11, the first fingers 152a are connected by wires 140 to the negative terminals 124 of each adjacent battery cell 62, and the second fingers 152b are connected by wires 140 to the positive terminals 120 of each adjacent battery cell 62. For two adjacent bus bars 66, the first fingers 152a of one bus bar 66 are aligned with the second fingers 152b of the adjacent bus bar 66 along a direction of the longitudinal axis 46 (FIG. 2). As such, the first fingers 152a of the one bus bar 66 extend away from the second fingers 152b of the adjacent bus bar 66, and the second fingers 152b of the one bus bar 66 extend toward the first fingers 152a of the adjacent bus bar 66.

[0073] Referring back to FIGS. 6 and 7, each battery cell assembly 18 includes primary bus bars 66a, 66b located at each longitudinal end (i.e., one at each end) of the first support member 102. The primary bus bar 66a extends along the lateral surface 116 of the first

support member 102 near a front edge thereof adjacent the first end 38 of the housing 14 and connects to the main positive or negative terminal 126 or 127 of the battery pack assembly 10. The primary bus bar 66b extends along the lateral surface 116 of the first support member 102 near a rear edge thereof adjacent the second end 42 of the housing 14 and connects to an intermediate positive or negative terminal 164 or 168 of the battery cell assembly 18. For the battery cell assembly 18 having the main positive terminal 126, the primary bus bar 66a connects to the positive terminals 120 of the adjacent battery cells 62 (via the wires 140) and the primary bus bar 66b connects to the negative terminals 124 of the adjacent battery cells 62. Conversely, for the battery cell assembly 18 having the main negative terminal 127, the primary bus bar 66a connects to the negative terminals 124 of the adjacent battery cells 62 and the primary bus bar 66b connects to the positive terminals 120 of the adjacent battery cells 62.

[0074] In addition to connecting the fingers 152a, 152b to the battery cells 62 as described above, the wires 140 can also be bonded to other components to form additional electrical connections within the battery pack assembly 10. For example, the wires 140 can also connect each bus bar 66 to the voltage sensing PCB 136. In the same or other embodiments, the wires 140 can form one or more electrical connections between the voltage sensing PCB 136 and the main PCB 94. In addition, the wires 140 can connect the primary bus bars 66b of the two battery cell assemblies 18 to each other to electrically connect the two battery cell assemblies 18 to one another. In some embodiments, the wires 140 can form a fusible connection between the two primary bus bars 66b. By utilizing the wires 140 to form other electrical connections in the battery pack assembly 10 in addition to the connections between the bus bars 66 and the battery cells 62, manufacturing efficiency is improved.

[0075] FIGS. 15 and 16 illustrate an embodiment of the battery cell assemblies 18 in which the bus bars 66 are arranged to alternatingly face toward or away from the lateral surface 116 of the first support member 102 when moving along a direction of the longitudinal axis 46. More specifically, for two adjacent bus bars 66, one of the adjacent bus bars 66 is oriented with the base 148 closer to the lateral surface 116 than the fingers 152a, 152b, and the other of the adjacent bus bars 66 is oriented with the fingers 152a, 152b closer to the lateral surface 116 than the base 148. In addition, as illustrated schematically in FIG. 16, each pair of two adjacent bus bars 66 of the battery cell assemblies 18 is arranged with

the fingers 152a, 152b of both bus bars 66 aligned along a flat plane P3. In other words, the fingers 152a, 152b of all of the bus bars 66 are arranged in-plane with one another and the bases 148 are arranged out of plane with one another. In other embodiments (not shown), the fingers 152a, 152b can still be arranged in-plane with one another but the bus bars 66 can each face the same direction, e.g., such that each of the bases 148 are adjacent the lateral surface 116, or each of the fingers 152a, 152b is adjacent the lateral surface 116.

[0076] FIGS. 17 and 18 illustrate another embodiment of the battery cell assemblies 18 similar to the embodiment of FIGS. 15 and 16, except that the fingers 152a, 152b of adjacent bus bars 66 are arranged out-of-plane with each other. Specifically, like the embodiment of FIGS. 15 and 16, the bus bars 66 of the embodiment of FIGS. 17 and 18 are arranged to alternatingly face toward or away from the lateral surface 116 of the first support member 120. But unlike the embodiment of FIGS. 15 and 16, the bus bars 66 of the embodiment of FIGS. 17 and 18 are arranged so that adjacent bus bars 66 have their fingers 152a, 152b located out-of-plane with each other. Similarly, the bases 148 of the adjacent bus bars 66 are also arranged out-of-plane with each other. The fingers 152a, 152b of the one bus bar 66 are centered about a fourth plane P4, the fingers 152a, 152b of the adjacent bus bar 66 are centered about a fifth plane P5, the base 148 of the one bus bar 66 is centered about a sixth plane P6, and the base 148 of the adjacent bus bar 66 is centered about a seventh plane P7, where each of the planes P4, P5, P6, and P7 are parallel to each other and offset from one another.

[0077] FIG. 19 illustrates another embodiment of the battery cell assemblies 18 in which the bus bars 66 are formed having a non-linear shape. Specifically, the bus bars 66 are formed having a zig-zag shape and do not include any fingers. The zig-zag bus bars 66 are positioned between adjacent columns of the battery cells 62, and adjacent zig-zag bus bars 66 are alternatingly arranged such that bent portions 172 of the bus bars 66 alternatingly protrude toward each other and away from each other.

[0078] FIG. 20 illustrates another embodiment of the battery cell assemblies 18 in which the bus bars 66 are formed having a non-linear shape. Specifically, the bus bars 66 include rounded cutouts 176 formed along each lateral side and corresponding to the outside diameter of the battery cells 62. The bus bars 66 are positioned between adjacent columns of the battery cells 62, and adjacent bus bars 66 are alternatingly arranged such that the rounded cutouts 176 of the bus bars 66 alternatingly face toward each other and away from each other.

[0079] FIG. 21 illustrates another embodiment of the battery cell assemblies 18 in which the bus bars 66 include fingers 152a, 152b having unequal widths. Specifically, the fingers 152a, 152b located toward the longitudinal ends of the bus bars 66 are relatively smaller in width and the fingers 152a, 152b located toward the longitudinal center of the bus bars 66 are relatively larger in width. The fingers 152a, 152b of a single bus bar 66 are misaligned with each other along a direction of the longitudinal axis 46 (FIG. 2).

[0080] FIG. 22 illustrates another embodiment of the battery cell assemblies 18 in which the bus bars 66 are formed having an "L" shape. The bus bars 66 include a longitudinally extending long leg 180 located between the columns of the battery cells 62 and a laterally extending short leg 184 protruding from one end of the bus bar 66. The bus bars 66 are alternatingly arranged with the short leg 184 of one bus bar 66 being located adjacent the voltage sensing PCB 136 and the short leg 184 of the next adjacent bus bar 66 being distant from the voltage sensing PCB 136.

[0081] FIG. 23 schematically illustrates another embodiment of the battery cell assemblies 18 in which the fingers 152a, 152b of each bus bar 66 are staggered relative to each other and are spaced by alternating short and long intervals along a longitudinal direction of the bus bar 66. Moreover, adjacent bus bars 66 are horizontally "flipped" relative to one another, resulting in each of the second fingers 152b being horizontally aligned with one another along a direction of the longitudinal axis 46 (FIG. 2) and each of the first fingers 152a being horizontally misaligned. This arrangement results in the fingers 152a, 152b extending relatively closer toward the positive and negative terminals 120, 124 of the battery cells 62 and minimizes a length of the wires 140 for connecting the fingers 152a, 152b to the terminals 120, 124.

[0082] FIG. 24 schematically illustrates another embodiment of the battery cell assemblies 18 in which the fingers 152a, 152b of each bus bar 66 are staggered relative to each other and are spaced by alternating short and long intervals along a longitudinal direction of the bus bar 66. Moreover, adjacent bus bars 66 are horizontally "flipped" relative to one another. Moreover, the bus bars 66 vary in length and are vertically misaligned such that none of the fingers 152a, 152b are horizontally aligned with one another between adjacent bus bars 66 along a direction of the longitudinal axis 46 (FIG. 2).

[0083] FIG. 25 illustrates another embodiment of the battery cell assemblies 18 in which the bus bars 66 are formed as elongated flat linear bodies. Specifically, the bus bars 66 are rectangular and do not vary in width along their longitudinal length.

[0084] FIGS. 26 and 27 schematically illustrate embodiments of the battery cell assemblies 18 in which only the primary bus bars 66a, 66b are provided (only primary bus bars 66a are shown). As such, the embodiments of FIGS. 26 and 27 do not include bus bars 66 between the columns of battery cells 62. Instead, the battery cells 62 are electrically connected to each other in a series/parallel arrangement by the wires 140 themselves, which are attached by wire bonding. Specifically, the wires 140 extend to connect the positive and negative terminals 120, 124 of the battery cells 62 to establish a series/parallel arrangement. The wires 140 also connect the positive terminals of the battery cells 62 in the last column to the primary bus bars 66a. In other embodiments (not shown), the primary bus bars 66a, 66b can also be omitted.

[0085] FIG. 28 illustrates another embodiment of the battery cell assemblies 18 in which the bus bars 66 include fingers 152a, 152b that are directly connected to the positive and negative terminals 120, 124 of the battery cells 62 by precision welding.

[0086] In some embodiments, such as that of FIGS. 5A-8, 11, and 19-25, the bus bars 66, 66a, 66b are coupled to the lateral surface 116 by fasteners 134. In some embodiments, such as that of FIGS. 29-47, the bus bars 66, 66a, 66b are insert molded within the first and second support members 102, 104 and are therefore coupled to the first and second support members 102, 104 without fasteners. It should be understood that the following discussion of the first support member 102 of FIGS. 29-47 and the bus bars 66, 66a, 66b coupled thereto of the battery assembly 18 has the same or similar features as the first support member 102 and the bus bars 66, 66a, 66b of the embodiments of the battery assemblies 18 above unless otherwise noted.

[0087] As shown in FIG. 31 with respect to the first support member 102, the lateral surface 116 has a plurality of elongate recesses 200 that extend in vertical direction along the lateral surface 116 and are positioned between each column of recesses 108. The elongate recesses 200 are configured to receive the bus bars 66, 66a, 66b. As shown in FIG. 32, the elongate recesses 200 each have a first portion 204 with a lowermost surface that defines a first plane P8 and a second portion 216 with a lowermost surface that defines a second plane

P9. The second plane P9 is parallel to and offset from the first plane P8. The middle bus bars 66 include a second portion 216a positioned adjacent one of the adjacent column of recesses 108 and a second portion 216b positioned adjacent the other of the adjacent column of recesses 108. In the illustrated embodiments, the second portions 216a, 216b are aligned and therefore have lowermost surfaces within the same plane P9. In other embodiments, the second portions 216a, 216b may be staggered or have other suitable configurations. The second portions 216 of the outer elongate recesses 200a, 200b (e.g., the front and rear elongate recesses 200 that extend adjacent to the front and rear edges) extend from one side of the first portion 204. As shown, the front elongate recess 200a has second portions 216 that are positioned adjacent the front-most column of recesses 108 and the rear elongate recess 200b has second portions 216 that are positioned adjacent the rear-most column of recesses 108. Additionally, the front elongate recess 200a includes a top recess portion 200a' and the rear elongate recess 200b includes a top recess portion 200b'. The top recess portions 200a', 200b' are positioned in the top surface of the first support member 102 adjacent the front and rear edges.

[0088] In some embodiments, a plurality of apertures 230 (FIG. 31) extends through the lateral surface 116 and are configured to align with corresponding apertures 234 (FIG. 29) in the voltage sensing PCB 136. The aligned apertures 230, 234 are configured to receive a portion of the bus bars 66, 66a, 66b, as discussed in greater detail below.

[0089] In the illustrated embodiment, there are thirteen middle bus bars 66, a first primary bus bar 66a, and a second primary bus bar 66b. In other embodiments, there may be more or fewer middle bus bars 66. Each of the bus bars 66, 66a, 66b has a shape that is complementary to the shape of the corresponding recess 200, 200a, 200b in which the bus bar 66, 66a, 66b is positioned.

[0090] In the illustrated embodiment, the middle bus bars 66 each include a first portion 238 formed from an elongated conductive body 244 having a longitudinal ridge or base 248, a plurality of first fingers 252a protruding laterally outward from a first side of the base 248, and a plurality of second fingers 252b protruding laterally outward from an opposite second side of the base 248. The fingers 252a, 252b are generally equal in width and each project the same lateral distance outward from the base 248. The fingers 252a, 252b are generally flat and each extend within a first plane P10 (FIGS. 38 and 39). The base 248 is also generally flat and extends within a second plane P11 that is parallel to the first plane P10 and

offset therefrom. The base 248 defines a recess 254 extending along a length thereof. A first connecting section 256 connects the base 248 to the first fingers 252a and a second connecting section 260 connects the base 248 to the second fingers 252b. In the embodiment of FIGS. 29-39, the fingers 252a, 252b are aligned with each other along a longitudinal length of the bus bar 66. The middle bus bars 66 also include a second portion 262 that is coupled (e.g., via fasteners such as rivets or by any other suitable means). The second portion 262 is formed from a generally L-shaped conductive member. A first leg 262a of the L-shape is coupled to a bottom surface of the elongated conductive body 244 at a first end and extends beyond the first end of the elongated conductive body 244. A second leg 262b of the L-shape extends perpendicular from the first leg 262a.

[0091] Each of the primary bus bars 66a, 66b include a first portion 238 with a generally L-shaped conductive body 244. A first leg 244a of the L-shaped conductive body 244 that has a longitudinal ridge or base 248, a plurality of fingers 252 protruding laterally outward from one side of the base 248. That is, the rear bus bar 66b includes fingers 252 extending laterally outwardly from a first side of the base 248 (e.g., in a first direction towards the battery cells 62), and the front bus bar 66a has fingers 252 protruding laterally outward from the second side of the base 248 (e.g., in a second direction towards the battery cells 62). The fingers 252 are generally equal in width and each project the same lateral distance outward from the base 248. The fingers 252 are generally flat and each extend within a first plane P10 (FIGS. 42, 43, 46, 47). The base 248 is also generally flat and extends within a second plane P11 that is parallel to the first plane P10 and offset therefrom. A connecting section 256 connects the base 248 to the fingers 252. The second leg 244b of the L-shaped conductive body 244 is configured to receive and secure the respective positive 126, 164 and negative 127, 168 terminals, as discussed above. In the illustrated embodiment, the respective positive 126, 164 and negative 127, 168 terminals may be coupled to an aperture extending through the second legs via a press-fit engagement or another suitable type of engagement (e.g., a threaded engagement, etc.).

[0092] Like the middle bus bars 66, the primary bus bars 66a, 66b also include a second portion 262 that is coupled (e.g., via fasteners such as rivets or by any other suitable means) to the first portion 238 (e.g., the bottom surface of the first leg 244a). The second portion 262 is formed from a conductive member having a first leg 262a, an intermediate leg 262c extending from the first leg 262a, and second leg 262b extending from the intermediate leg

262c. The first leg 262a is coupled to a bottom surface of the first leg 244a of the first portion 238 at a first end. The intermediate leg 262c extends laterally outwardly from the first leg 262a. The second leg 262b extends perpendicular from the intermediate leg 262c.

[0093] In the illustrated embodiment, the first portion 238 of each of the bus bars 66, 66a, 66b is formed from a first conductive material, such as a material including aluminum or an aluminum alloy (e.g., AL 3003), and the second portion 262 of each of the bus bars 66, 66a, 66b is formed from a second, different conductive material, such as a material including copper or a copper alloy. In the illustrated embodiment, the second portion 262 is nickel and tin plated. That is, the second portion 262 has an outer layer that is formed from nickel and tin. In the illustrated embodiment, the respective positive 126, 164 and negative 127, 168 terminals may be formed of a third conductive material, such as a material including steel.

[0094] The bus bars 66, 66a, 66b are configured to be positioned within a corresponding elongate recess 200 of the first support member 102. Specifically, the base 248 is positioned within and supported by the first portion 204 of the corresponding elongate recess 200, while each of the fingers 252, 252a, 252b are positioned within and supported by a corresponding second portion 216, 216a, 216b of the elongate recess 200, 200a, 200b. With respect to the middle bus bars 66 in particular, each of the first fingers 252a is positioned in the second portion 216a and each of the second fingers 252b is positioned in the second portion 216b of the elongate recess 200. With respect to the outer bus bars 66a, 66b, the second leg 244b is positioned within the top recesses 200a', 200b'. Additionally, the recess 254 defined by the base 248 of each bus bar 66, 66a, 66b faces outwardly relative to the lateral surface 116. Also, when the bus bars 66, 66a, 66b are positioned in the respective elongate recess 200, 200a, 200b of the first support member 102, the second leg 262b of each of the second portions 262 is configured to be received in a pair of the aligned apertures 230, 234 of the lateral surface 116 and the voltage sensing PCB 136. Accordingly, a distal end of each of the second legs 262b extends from the lateral surface 116. As shown, the distal ends of each of the second legs 262b lie in the same plane P12. The second legs 262b of the bus bars 66, 66a, 66b are each soldered to the voltage sensing PCB 136 to electrically connect the bus bars 66, 66a, 66b with the voltage sensing PCB 136. Finally, a connection member 270 is positioned within the recess of each base 248 and integrally formed with the lateral surface 116 of the first support member 102 at opposite ends of the first portion of the bus bar 66, 66a, 66b. Specifically, the connection member 270 is formed by filling (e.g., via injection

molding) the recess 254 of the corresponding base 248 of each bus bar 66 with a plastic material that forms the rest of the first support member 102 such that each of the connection members 270 are integrally joined with the lateral surface 116 of the first support member 102 at opposite ends of the first portion 238 of the bus bar 66, 66a, 66b. As shown, the connection member 270 is elongate and linear and therefore leaves the fingers 252, 252a, 252b exposed for connection with the battery cells 626 via bonded wires 140, as discussed above. Accordingly, the bus bar 66 is coupled to the first support member 102 via injection molding rather than fasteners.

[0095] The following method may be used to form the battery assembly 18 of FIGS. 29-47. The first support member 102 and a second support member 104 may each be formed from a plastic material. A bus bar 66, 66a, 66b may be positioned within one of the elongate recesses 200, 200a, 200b of the first support member 102 and second support member 104. The connection members 270 may be formed by injecting the recess 254 of each of the bases 248 with the plastic material such that the plastic material fills the recess 254 and integrally forms with the respective first support member 102 and second support member 104. This process leaves the fingers 252, 252a, 252b exposed. The battery cells 62 are positioned between the first support member and the second support member. Wires are bonded between the fingers 252, 252a, 252b of each of the bus bars 66, 66a, 66b and either the positive terminal 126, 164 or the negative terminals 127, 168. The method further includes coupling (e.g., soldering) the second legs 262b of the second portions 262 of the bus bars 66, 66a, 66b to the voltage sensing PCB 136.

[0096] The shape of the elongate recesses 200, 200a, 200b and the shape of the corresponding bus bars 66, 66a, 66b of FIGS. 29-47 are merely exemplary. In other embodiments, the elongate recesses 200, 200a, 200b and the bus bars 66, 66a, 66b may have other suitable complementary shapes. For example, in some embodiments, the second portions 262 may be omitted from configuration of the bus bars 66, 66a, 66b of FIGS. 29-47. In such case, the bus bars 66, 66a, 66b may be otherwise electrically coupled to the voltage sensing PCB 136 in other ways (e.g., via wire bonding, welding, or any other suitable method). In another example, the elongate recesses 200, 200a, 200b may be shaped to accommodate any of the other bus bar 66, 66a, 66b configuration disclosed herein.

[0097] Although the disclosure has been described in detail with reference to certain preferred embodiments, variations and modifications exist within the scope and spirit of one or more independent aspects of the disclosure as described.

CLAIMS

What is claimed is:

1. A mobile power source comprising:

a battery pack including at least two battery cell assemblies, each battery cell assembly including

a plurality of battery cells each having a first end, a second end opposite the first end, a positive terminal located at the first end and a negative terminal located at the first end,

a frame having a first support member and a second support member, each of the first and second support members including a plurality of cylindrical recesses that receive the plurality of battery cells to support the battery cells, and

bus bars coupled to the first support member via injection molding and configured to electrically connect to at least two battery cells, each bus bar including an elongated conductive body having a base and fingers extending laterally away from the base;

wherein the fingers extend within a first plane, and wherein the base extends within a second plane that is parallel to the first plane and offset therefrom.

2. The mobile power source of claim 1, wherein each of the bus bars each include a first portion that includes the base and the fingers and a second portion coupled between the first portion and a voltage sensing PCB.

3. The mobile power source of claim 2, wherein the first portion is formed from a first material and the second portion is formed from a second material that is different than the first material.

4. The mobile power source of claim 1, wherein the bus bars include a first outer bus bar, a second outer bus bar, and middle bus bars positioned between the first outer bus bar and the second outer bus bar, and wherein

the fingers of the first outer bus bar extend from the base in a first direction,

the fingers of the second outer bus bar extend from the base in a second direction, and

the fingers of the middle bus bars include first fingers extending in the first direction from the base and second fingers extending in the second direction from the base.

5. The mobile power source of claim 4, wherein the first fingers and the second fingers are aligned along a longitudinal length of the base.

6. The mobile power source of claim 4, further comprising

first wires that connect the fingers of one of the first outer bus bar or the second outer bus bar to the negative terminals of at least two battery cells and the first fingers of each of the middle bus bars to the negative terminals of at least two battery cells, and

second wires that connect the fingers of the other of the first outer bus bar or the second outer bus bar to the positive terminals of at least two battery cells and the second fingers of each of the middle bus bars to the positive terminals.

7. The mobile power source of claim 1, wherein wires connect the fingers of the bus bars to either the positive terminal or the negative terminals.

8. A mobile power source comprising:

a battery pack including at least two battery cell assemblies, each battery cell assembly including

a plurality of battery cells each having a first end, a second end opposite the first end, a positive terminal located at the first end and a negative terminal located at the first end,

a frame having a first support member and a second support member, each of the first and second support members including a plurality of cylindrical recesses arranged in vertical columns that receive the plurality of battery cells to support the battery cells and elongate recesses, each of the elongate recesses positioned adjacent to at least one column of the plurality of cylindrical recesses; and

a bus bar positioned within each of the plurality of elongate recesses of the first support member and configured to electrically connect to at least two battery cells, each of the bus bars including an elongated conductive body having a base and fingers extending laterally away from the base, the base defining a recess, the fingers extending within a first plane and the base extending within a second plane that is parallel to the first plane and offset therefrom;

a connection member positioned within the recess in each base and integrally formed with the first support member to couple the corresponding bus bar to the first support member; and

wires that connect the fingers of each the bus bars to either the positive terminal or the negative terminals.

9. The mobile power source of claim 8, wherein each of the bus bars include a first portion that includes the base and the fingers and a second portion coupled between the first portion and a voltage sensing PCB.

10. The mobile power source of claim 9, wherein the first portion is formed from a first material and the second portion is formed from a second material that is different than the first material.

11. The mobile power source of claim 9, wherein the first portion is formed from a material formed from aluminum and the second portion is formed from a material that formed from copper.

12. The mobile power source of claim 8, wherein the bus bar positioned in a first outer elongated recess is a first outer bus bar, the bus bar positioned in a second outer elongated recess is a second outer bus bar, and the bus bars positioned within middle recesses positioned between the first outer recess and the second outer recess are middle bus bars, and wherein

the fingers of the first outer bus bar extend from the base in a first direction,

the fingers of the second outer bus bar extend from the base in a second direction, and

the fingers of the middle bus bars include first fingers extending in the first direction from the base and second fingers extending in the second direction from the base.

13. The mobile power source of claim 12, wherein the first fingers and the second fingers are aligned along a longitudinal length of the base.

14. The mobile power source of claim 12, wherein the wires include

first wires that connect the fingers of one of the first outer bus bar or the second outer bus bar to the negative terminals of at least two battery cells and the first fingers of each of the middle bus bars to the negative terminals of at least two battery cells, and

second wires that connect the fingers of the other of the first outer bus bar or the second outer bus bar to the positive terminals of at least two battery cells and the second fingers of the middle bus bars to the positive terminals.

15. The mobile power source of claim 8, wherein the bus bars are coupled to the first support member without fasteners.

16. A method of forming a mobile power supply, the method comprising:

forming a frame having a first support member and a second support member, each of the first and second support members being formed from a plastic material and including a plurality of cylindrical recesses arranged in vertical columns that receive the plurality of battery cells to support the battery cells and elongate recesses, each of the elongate recesses positioned adjacent to at least one column of the plurality of cylindrical recesses;

positioning a bus bar within one of the elongate recesses of the first support member, each bus bar including an elongated conductive body having a base and fingers extending laterally away from the base, the base defining a recess, the fingers extending within a first plane and the base extending within a second plane that is parallel to the first plane and offset therefrom;

injecting the recess of each of the bases with the plastic material such that the plastic material fills the recess and integrally forms with the first support member;

positioning a plurality of battery cells between the first support member and the second support member such that the plurality of cylindrical recesses of the first support member and the second support member support the plurality of battery cells, each of the battery cells having a first end, a second end opposite the first end, a positive terminal located at the first end, and a negative terminal located at the first end; and

wire bonding wires between the fingers each of the bus bars and either the positive terminal or the negative terminals.

17. The method of claim 16, wherein injecting the recess of each of the bases with the plastic material such that the plastic material integrally forms with the first support member includes leaving the fingers exposed.

18. The method of claim 16, wherein each of the bus bars include a first portion having the base and the fingers and a second portion coupled to and extending from the first portion, the first portion being formed of a first conductive material and the second portion being formed of a second conductive material that is different from the first conductive material.

19. The method of claim 18, further comprising coupling the second portion to a voltage sensing PCB.

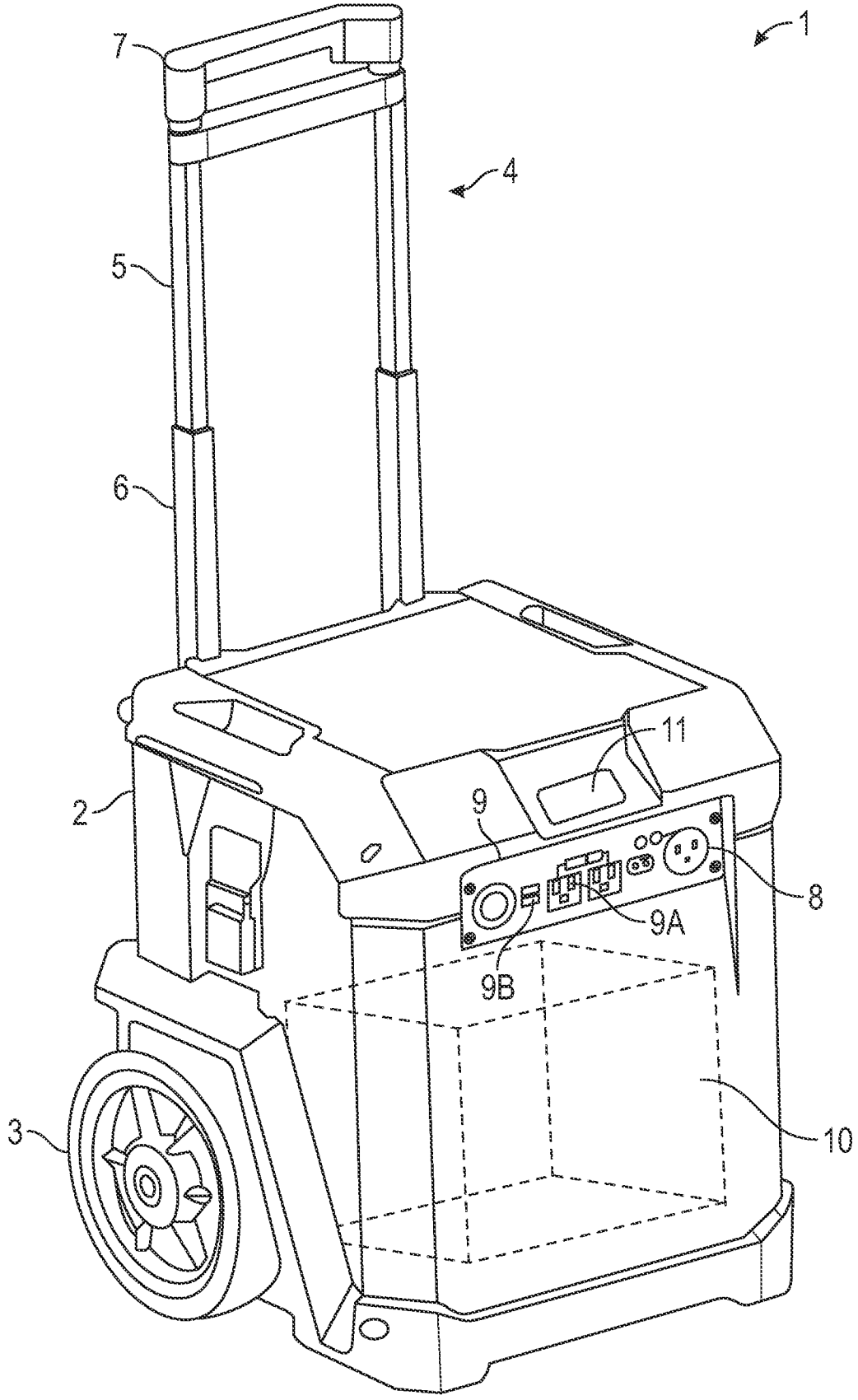


FIG. 1

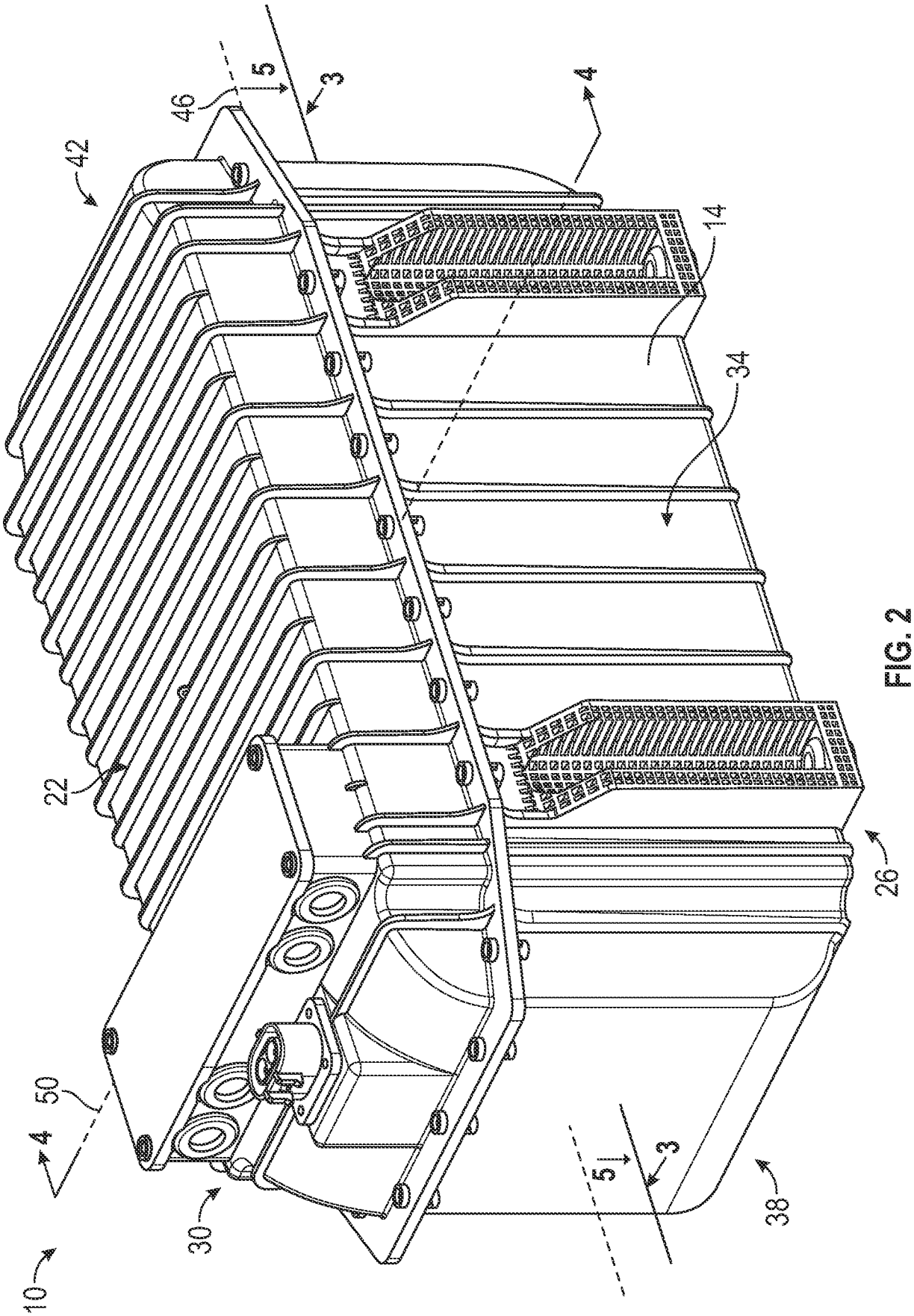


FIG. 2

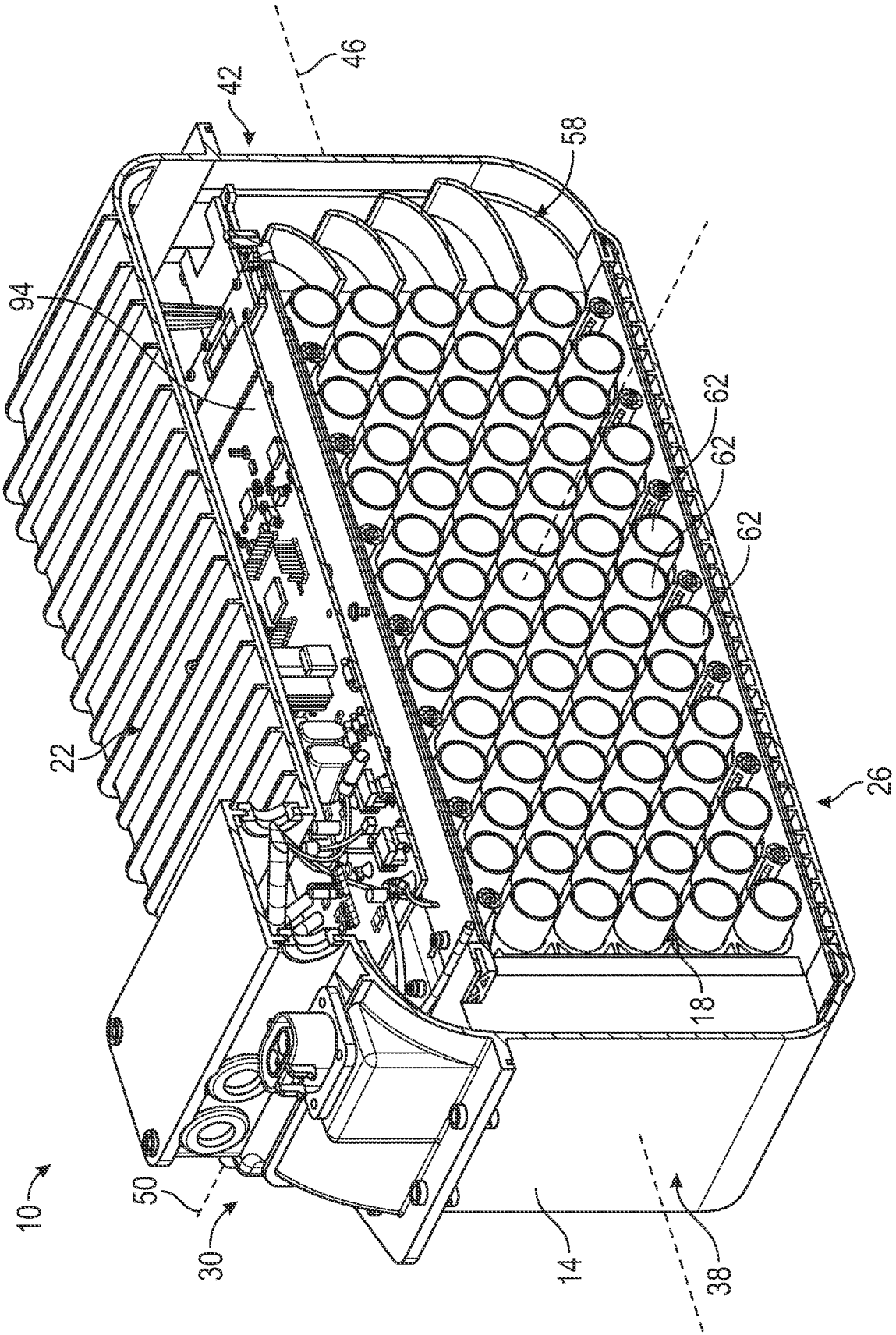


FIG. 3

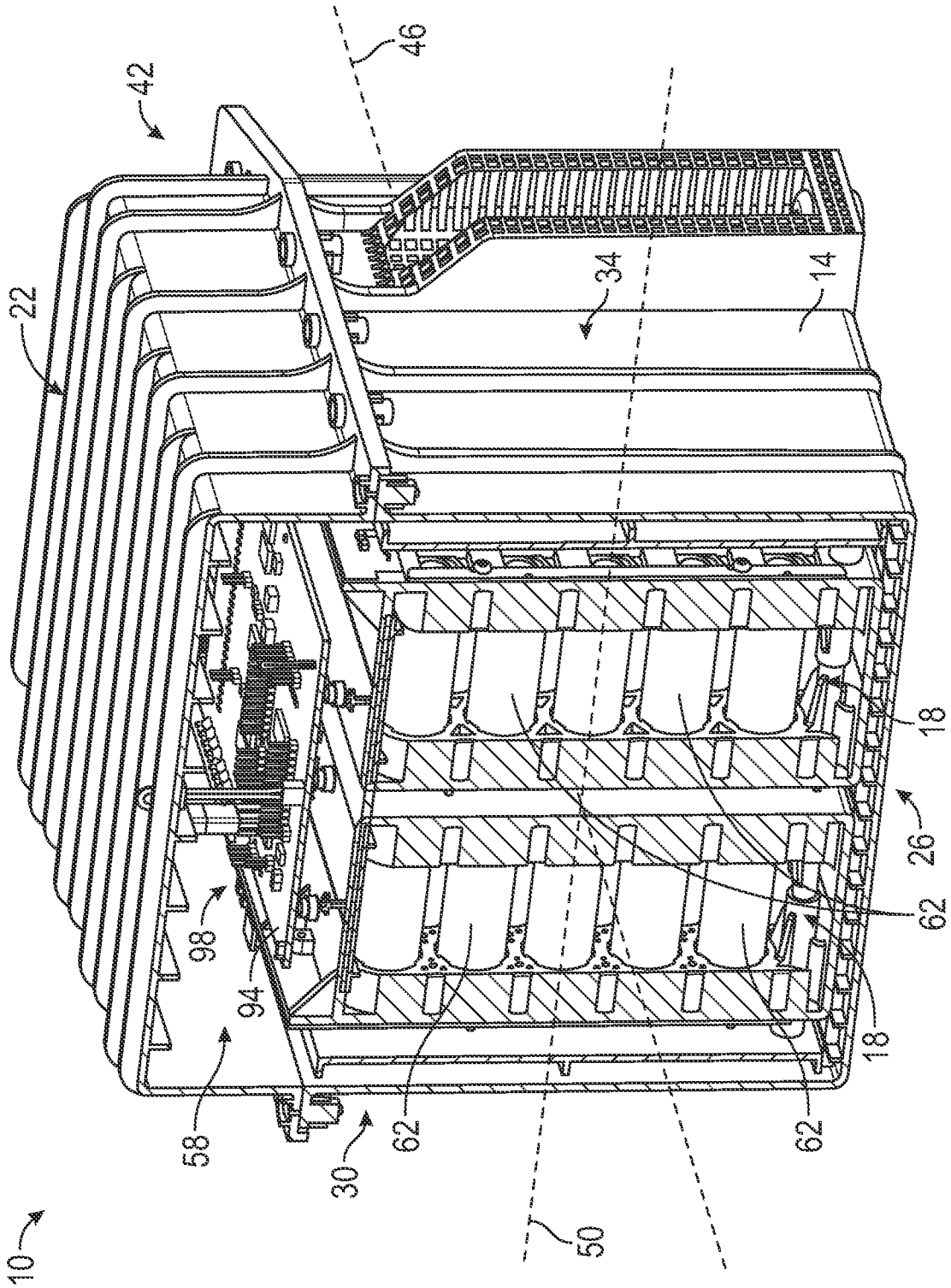


FIG. 4

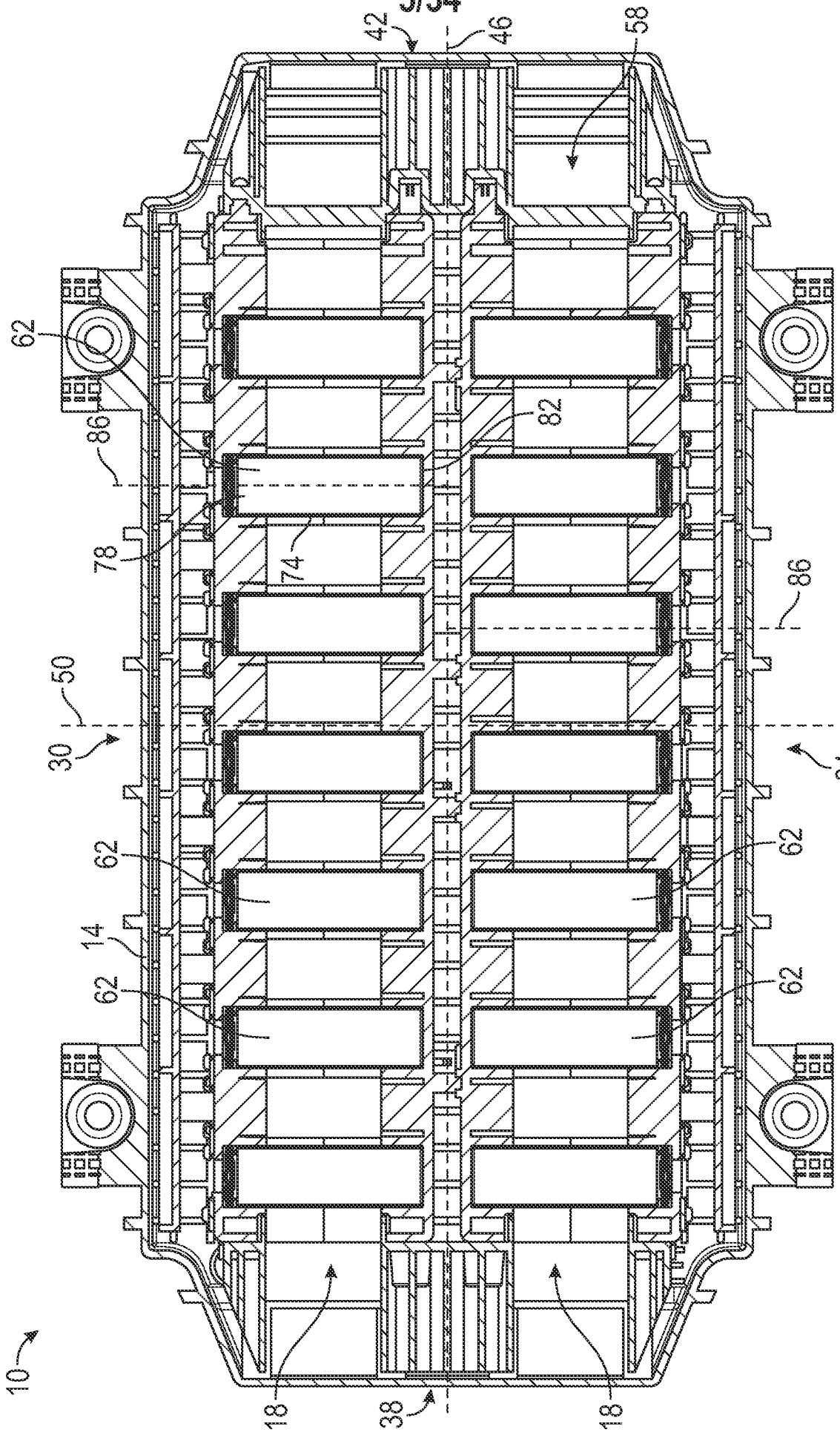


FIG. 5

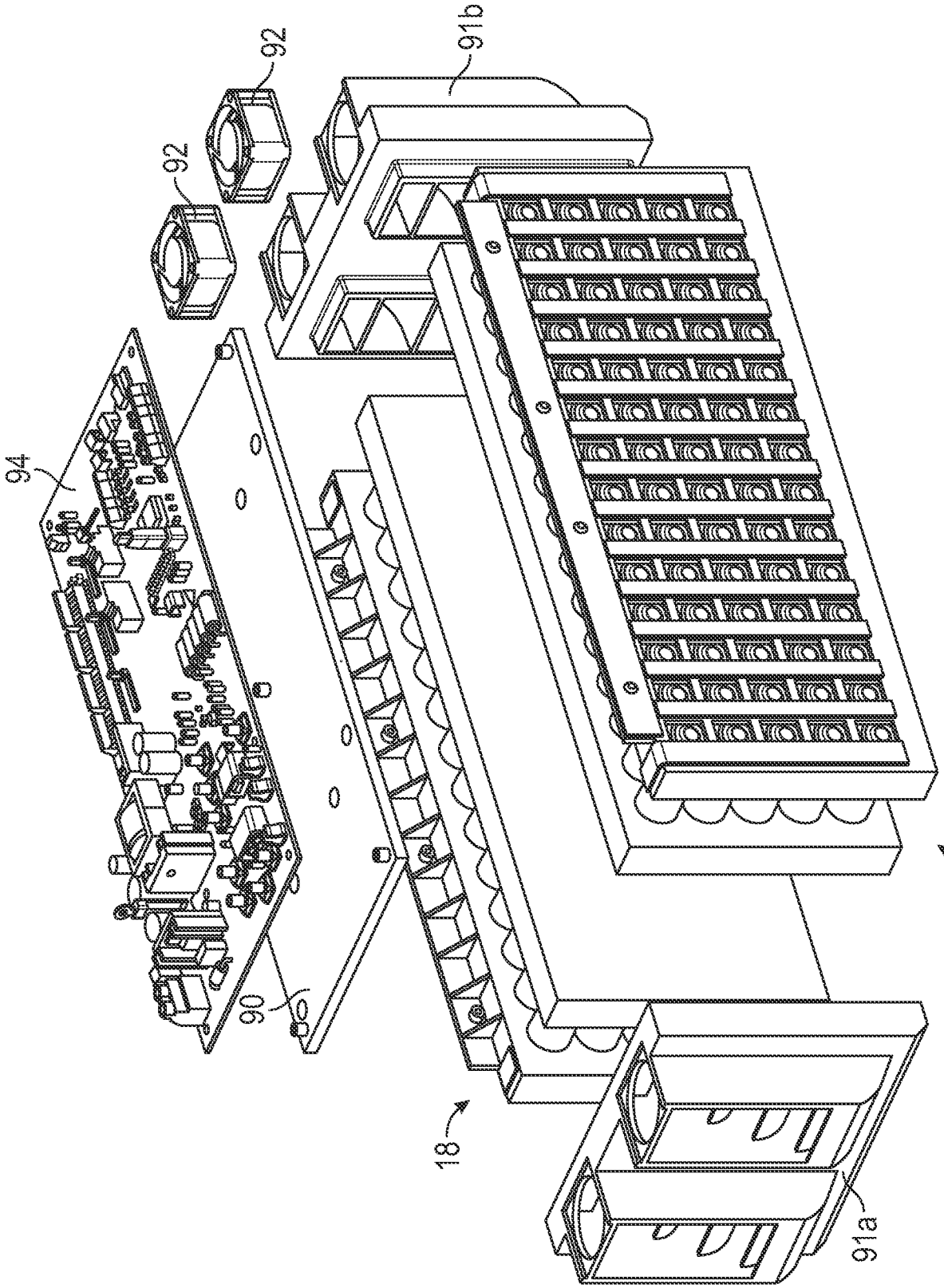


FIG. 5A

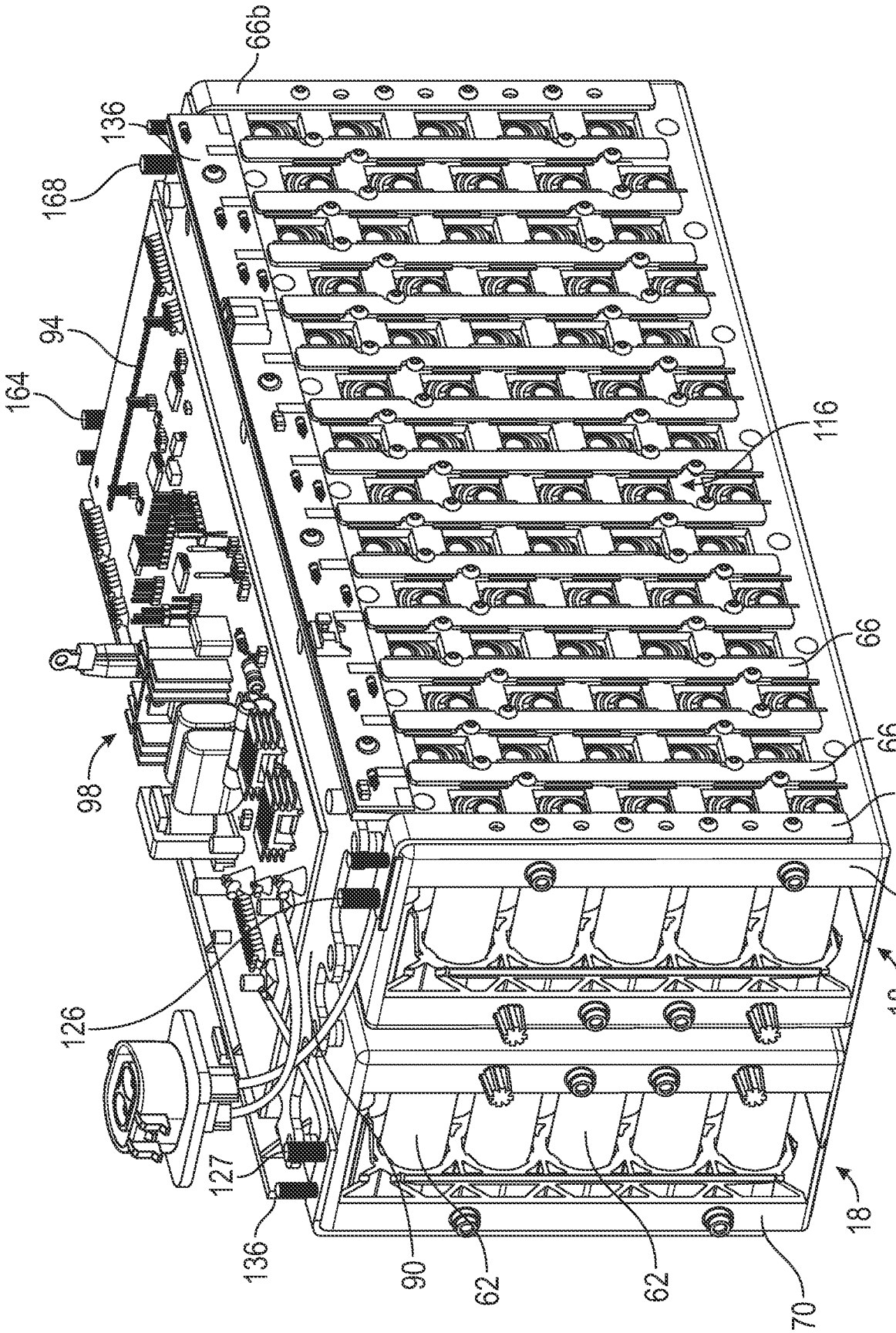


FIG. 6

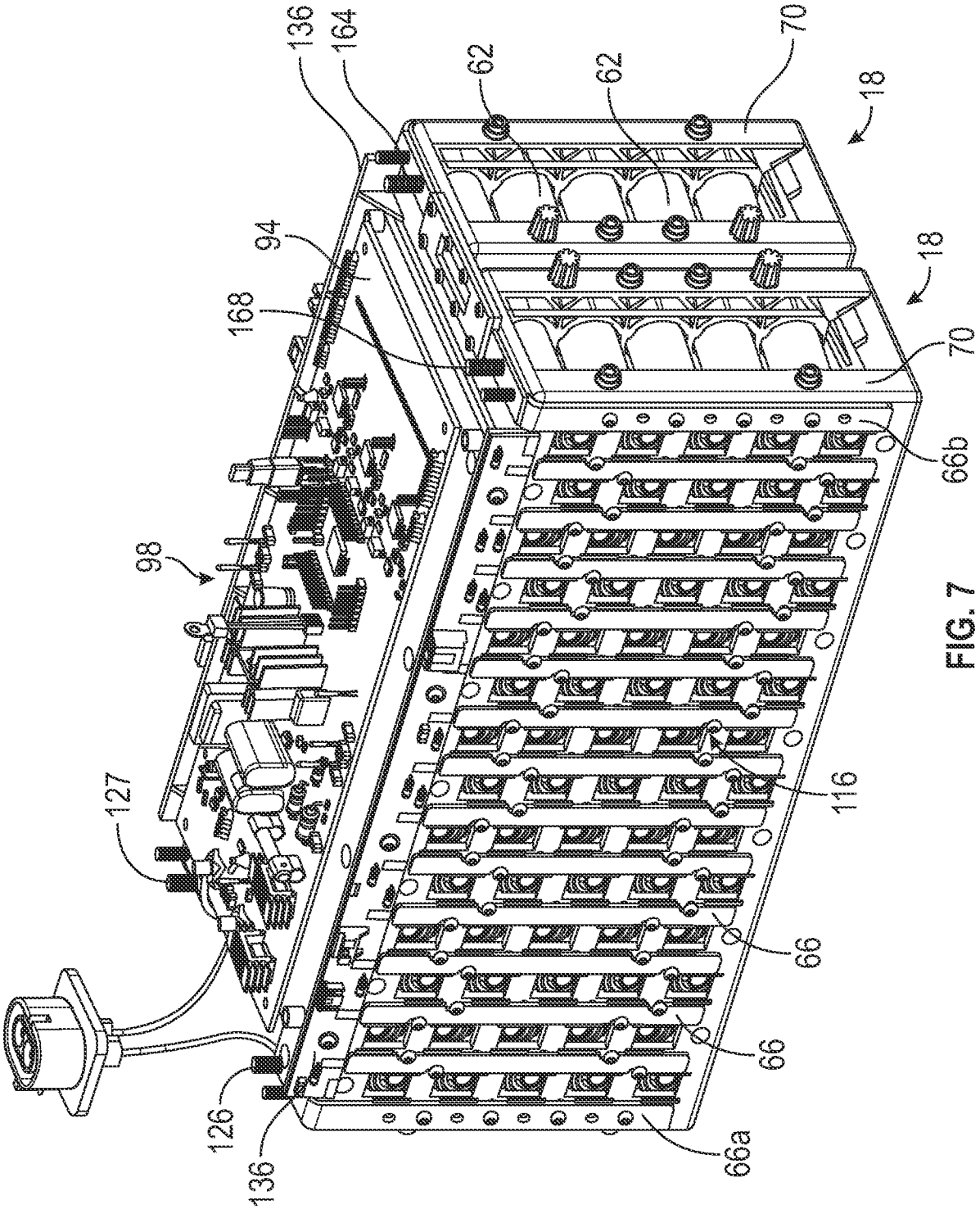


FIG. 7

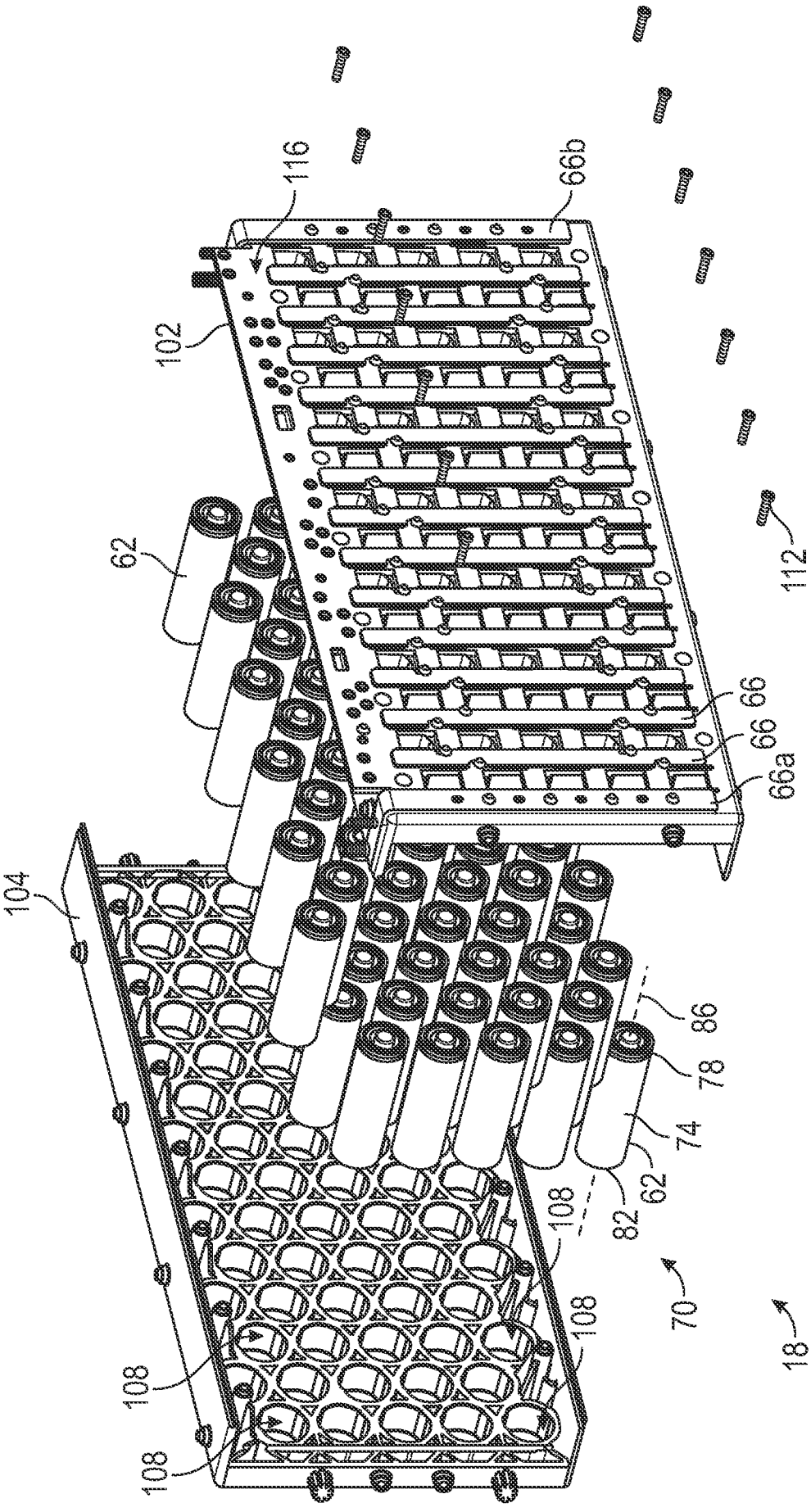

116
66b
102
62
112
66
66
66a
104
86
78
74
62
82
108
108
108
108
70
18

FIG. 8

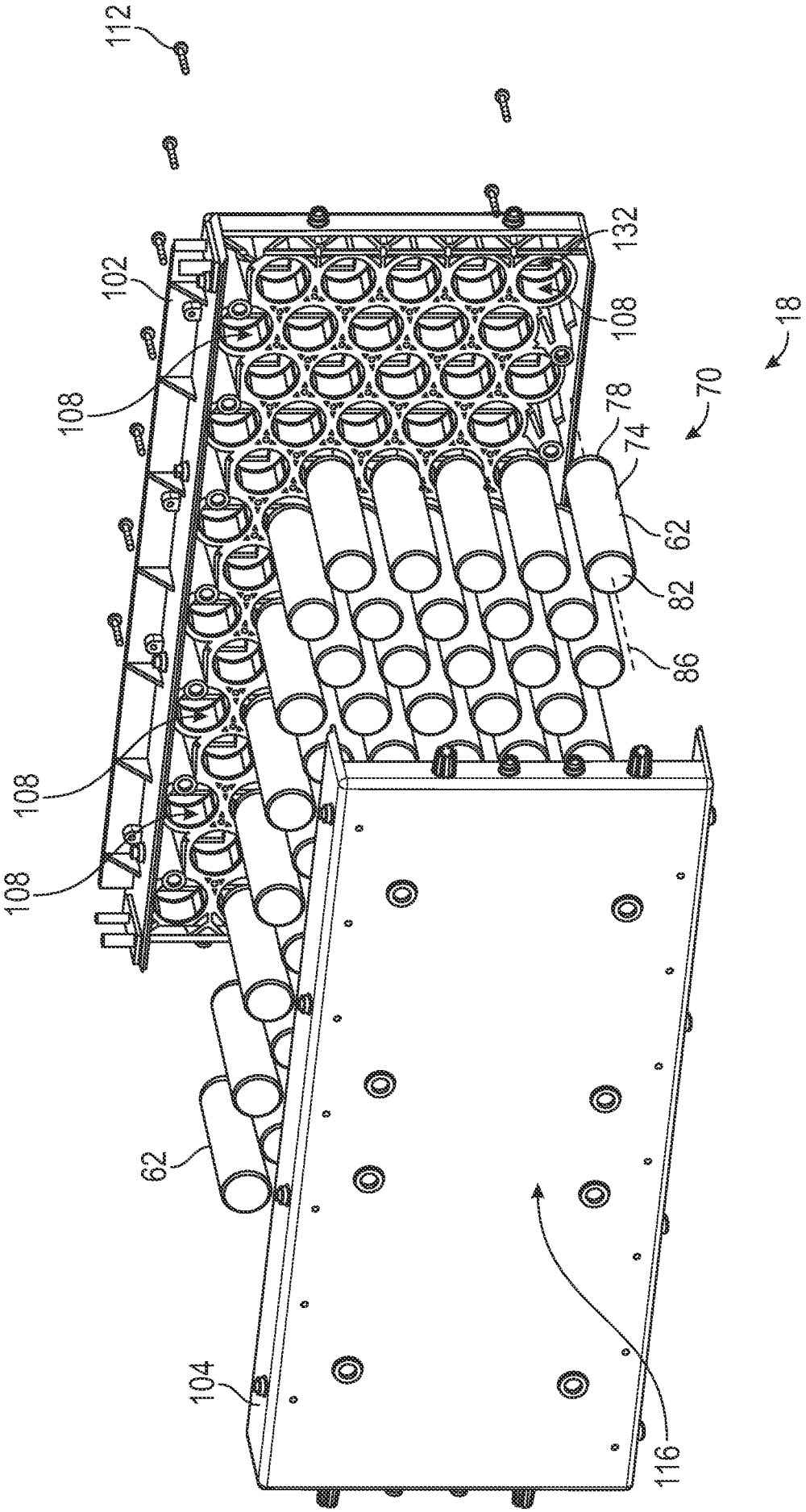


FIG. 9

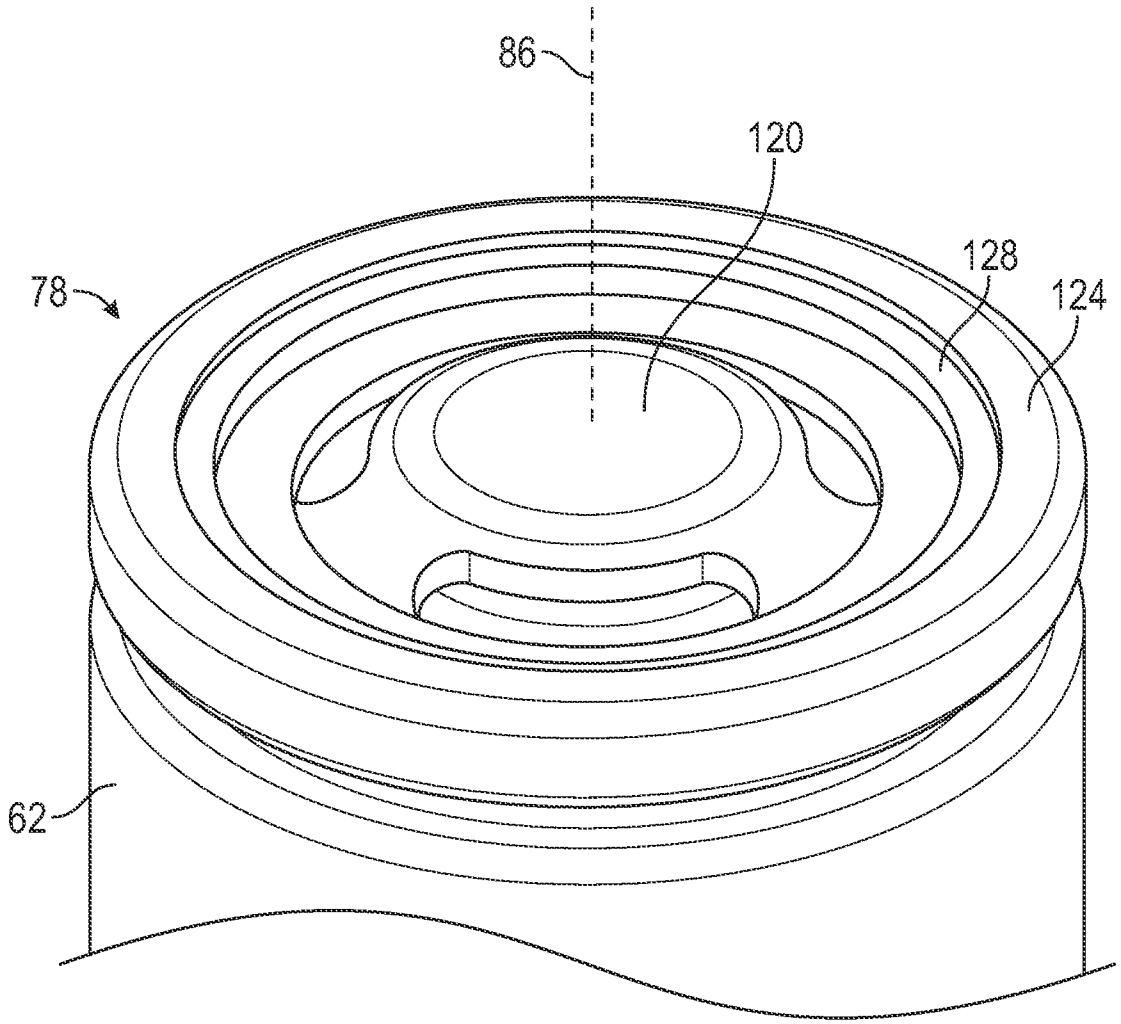


FIG. 10

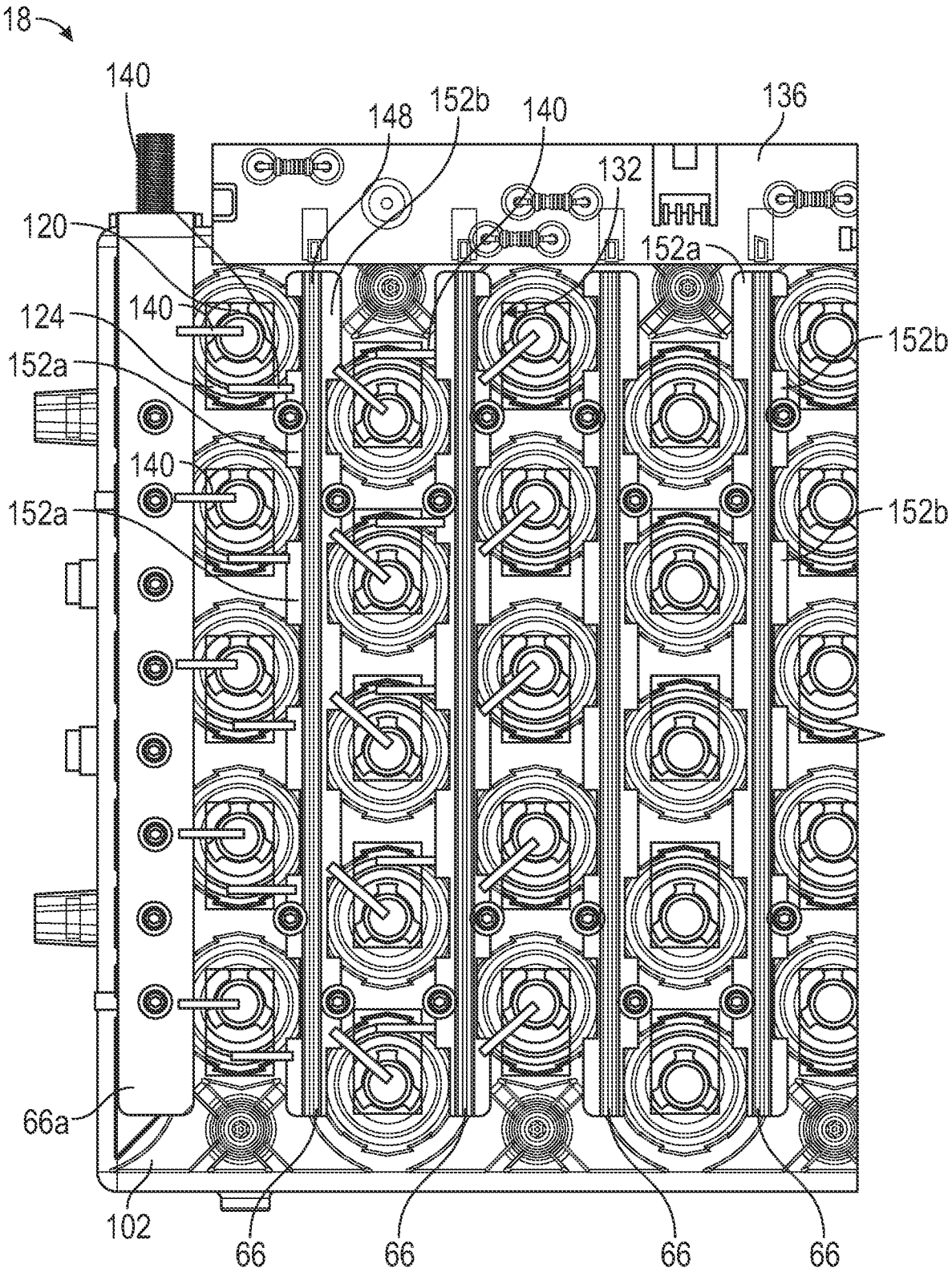

18
140
148
152b
140
136
132
120
152a
124
140
152b
152a
140
152a
152b
66a
102
66
66
66
66

FIG. 11

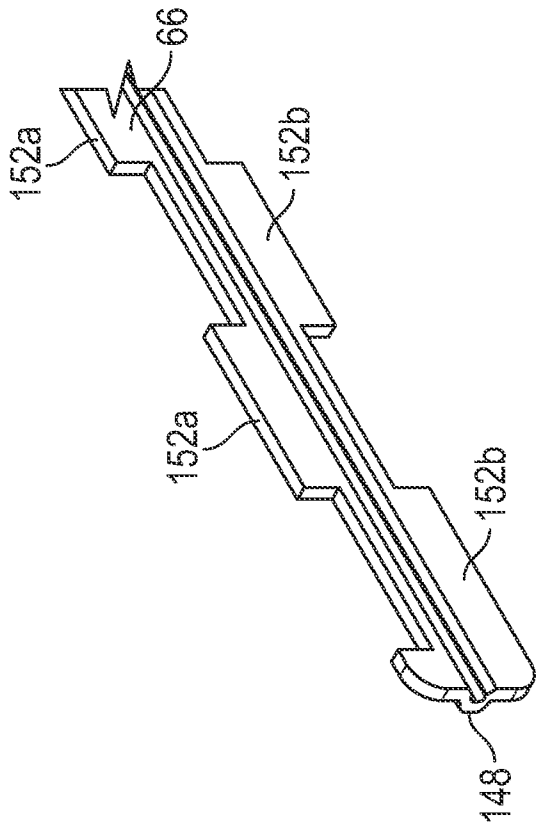


FIG. 13

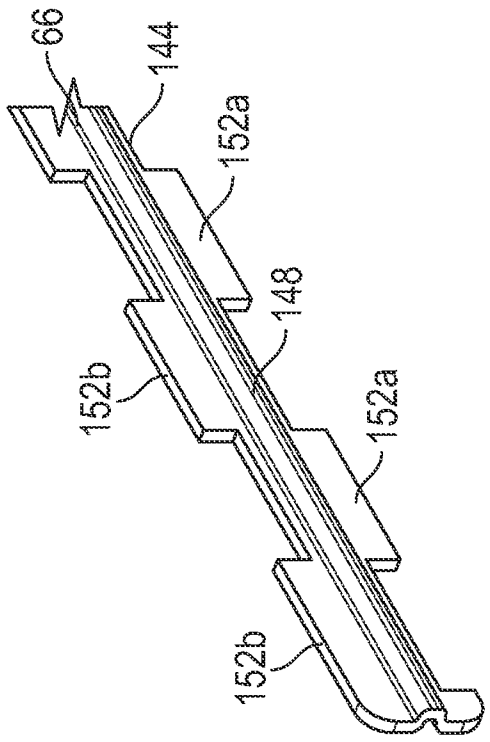


FIG. 12

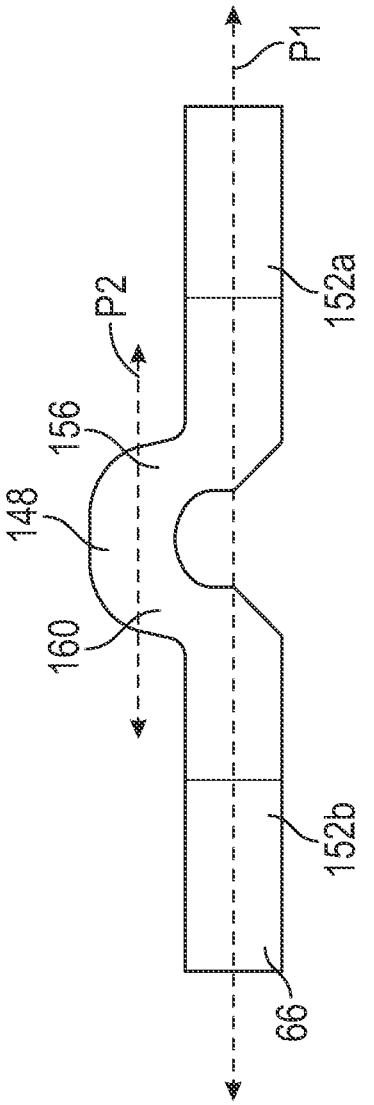


FIG. 14

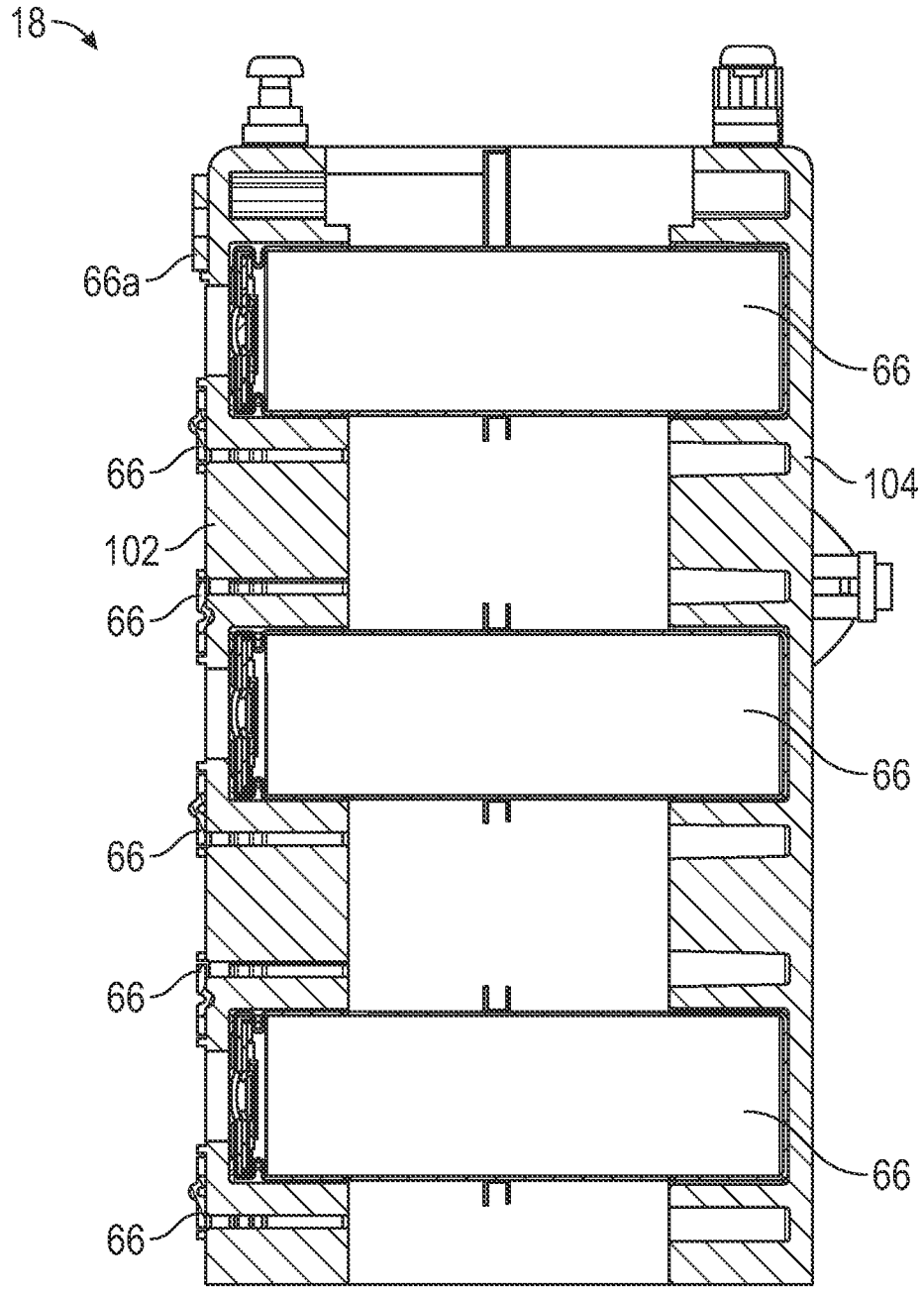

18
66a
66
66
104
102
66
66
66
66
66
66

FIG. 15

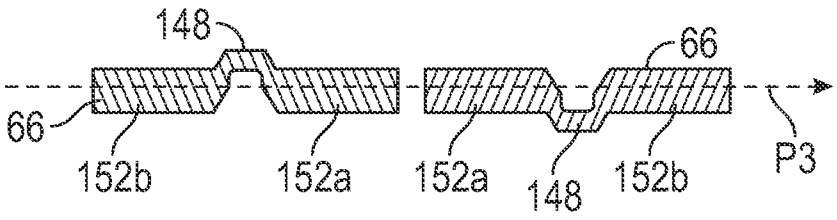

148
66
66
152b
152a
152a
148
152b
P3

FIG. 16

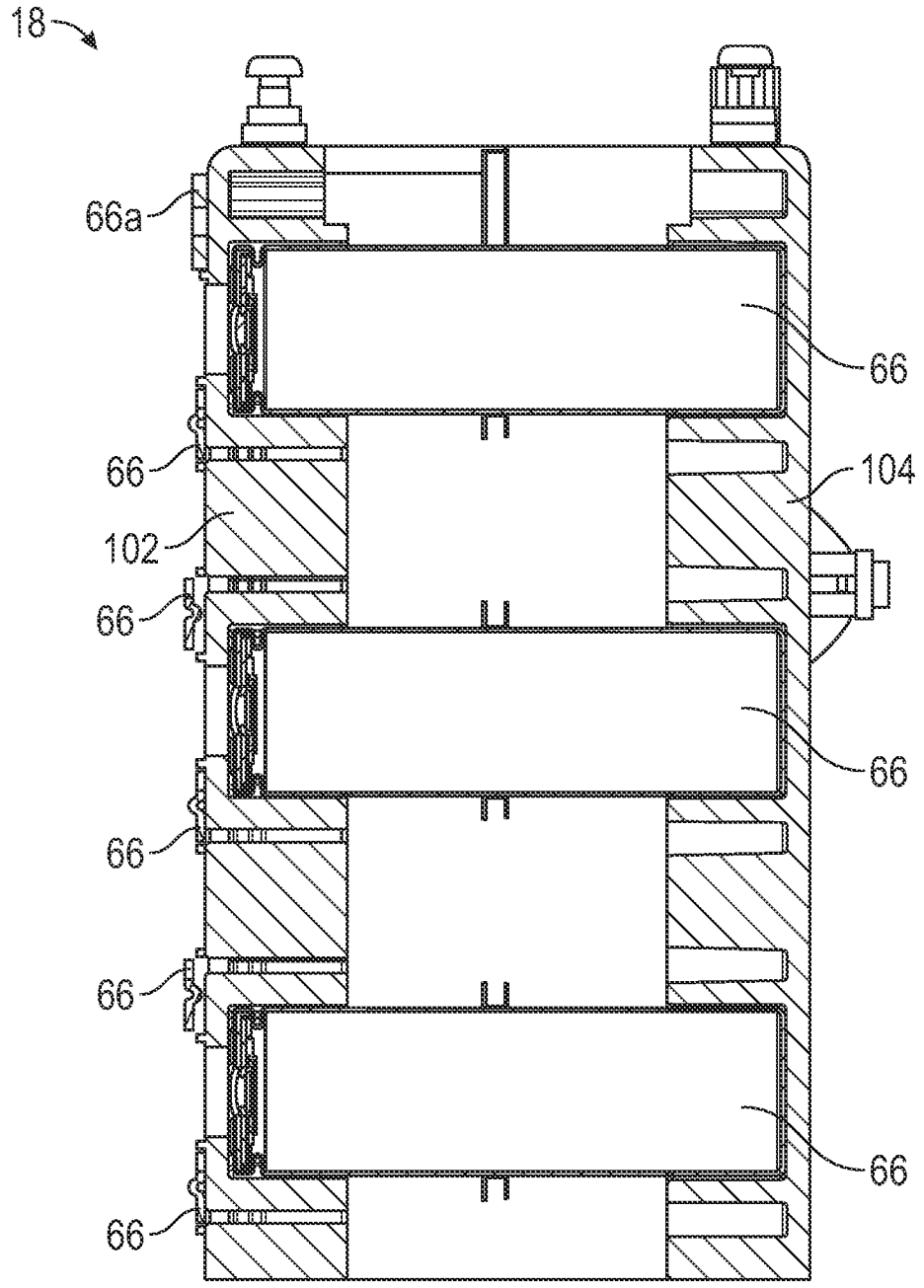

18
66a
66
66
104
102
66
66
66
66
66
66

FIG. 17

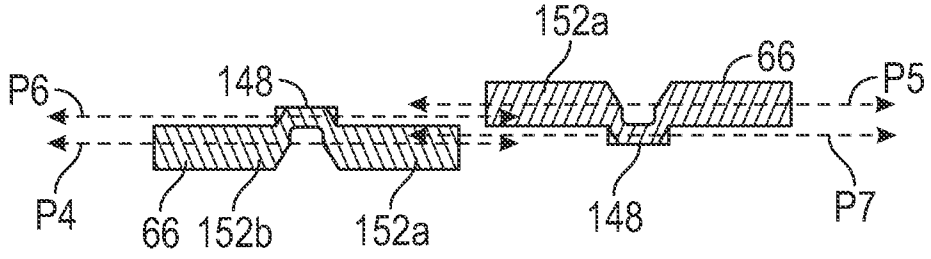

152a
66
P6
148
P5
P4
66
152b
152a
148
P7

FIG. 18

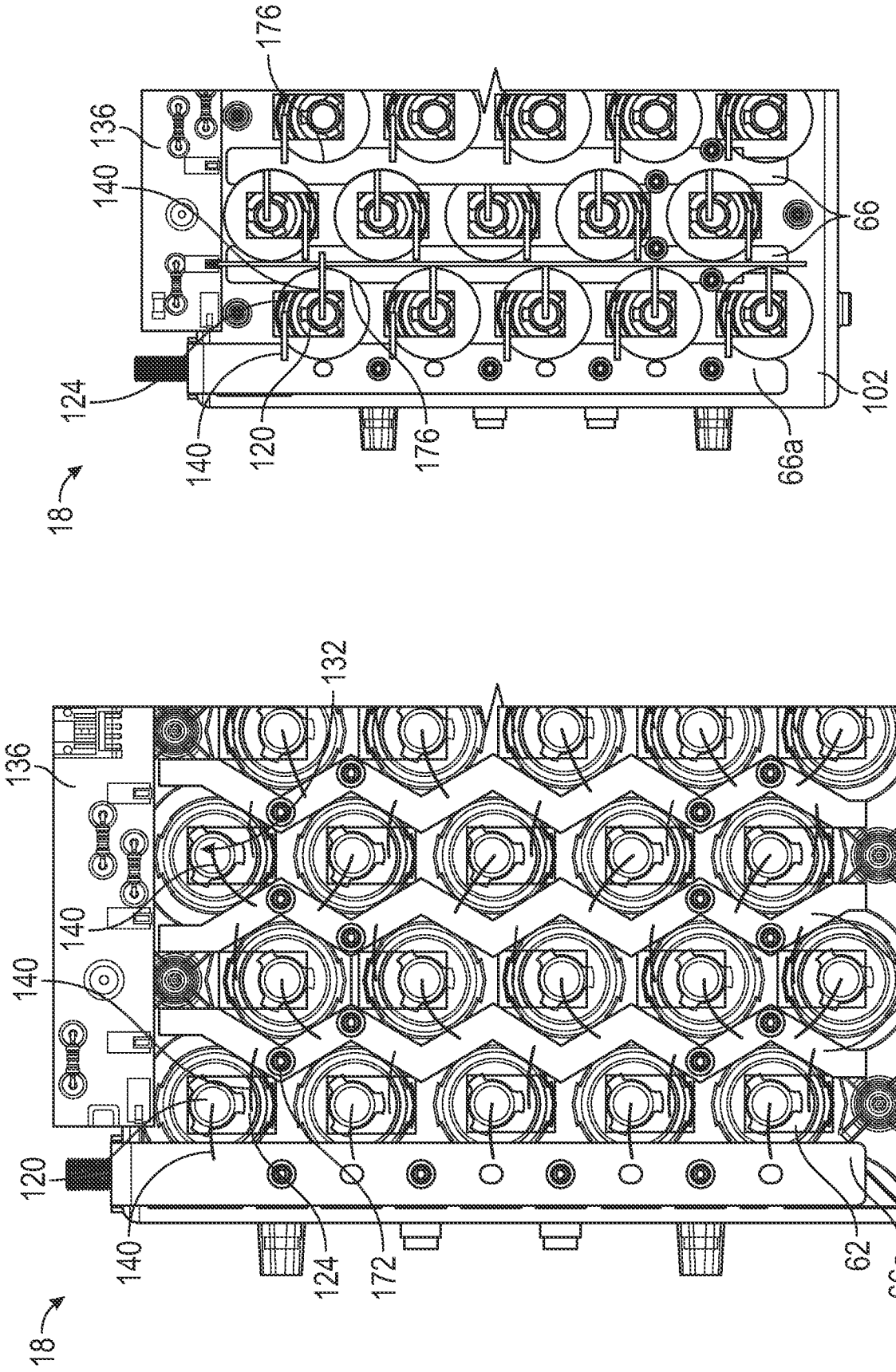

176
136
140
66
124
102
140
120
176
66a
18

FIG. 20

132
136
140
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66
120
102
140
124
172
62
66a
18

FIG. 19

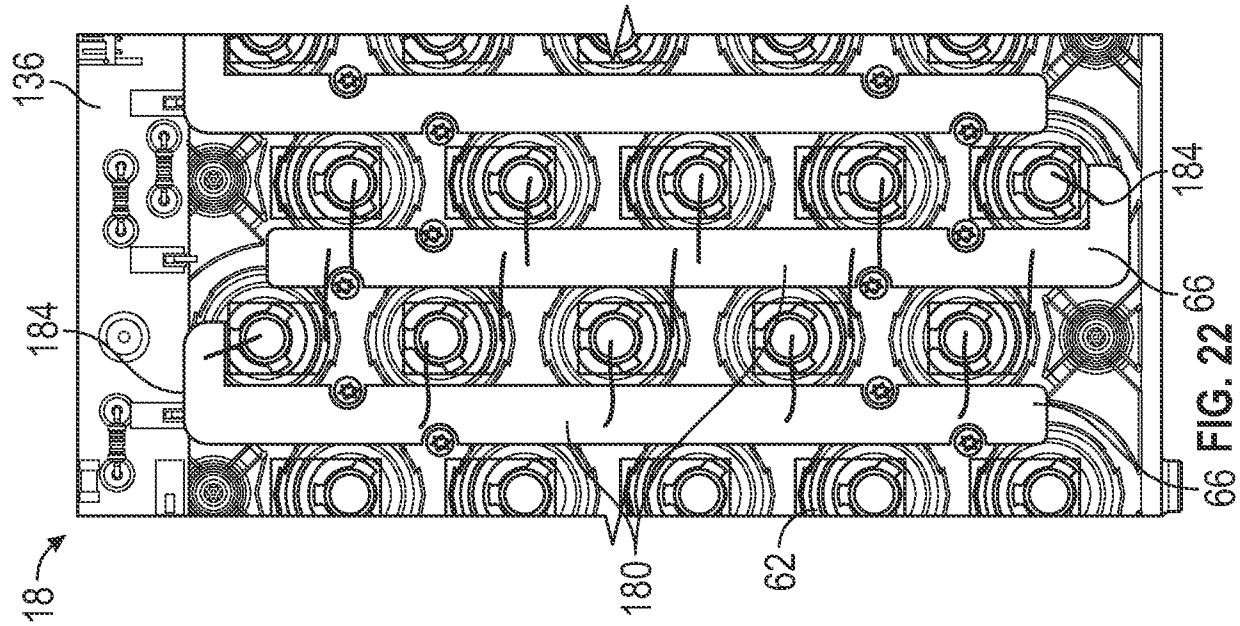

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184
184
66
66
66
18
180
62

FIG. 22

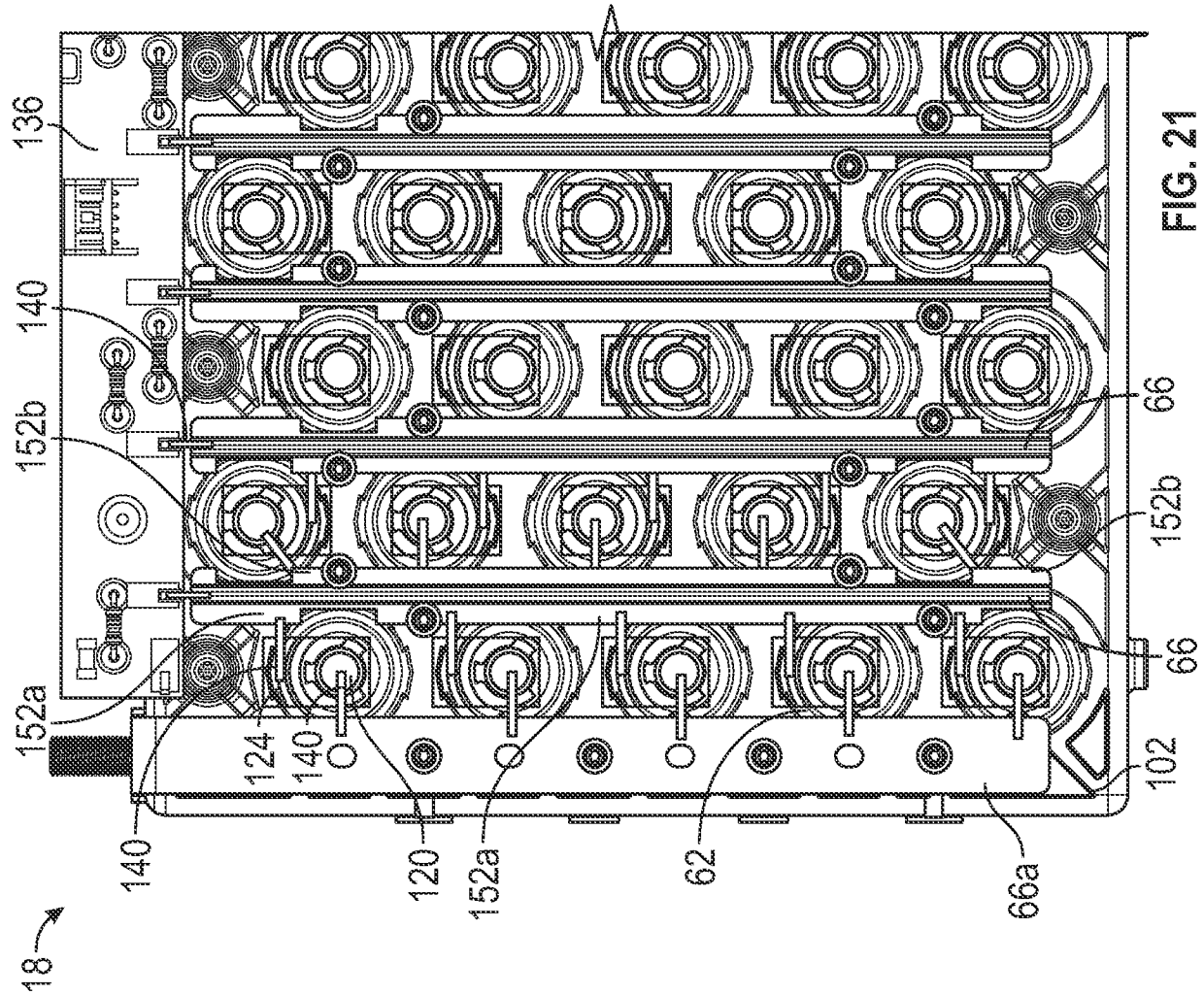

136
140
152b
66
152b
66
152a
124
140
102
140
120
152a
62
66a
18

FIG. 21

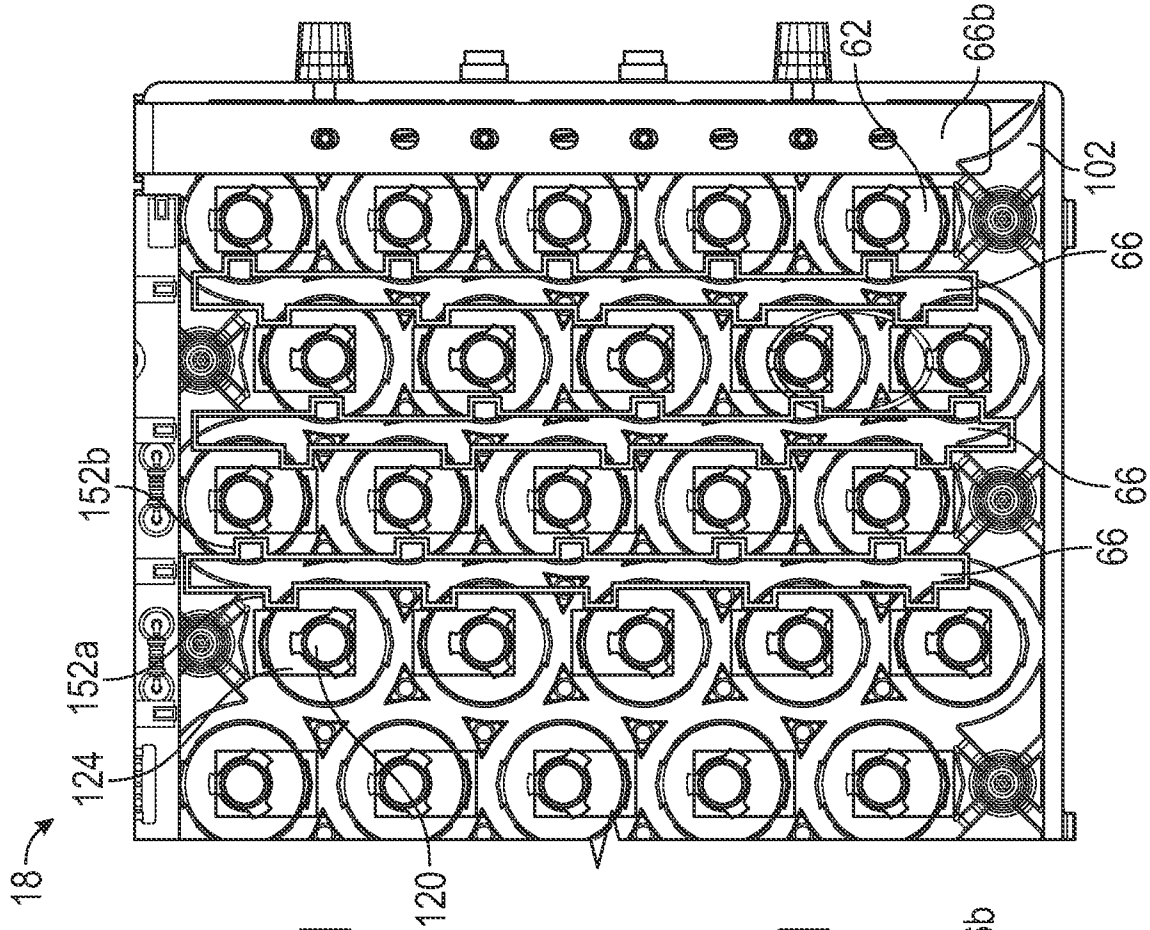

62
66b
102
66
66
66
152b
152a
124
120
18

FIG. 24

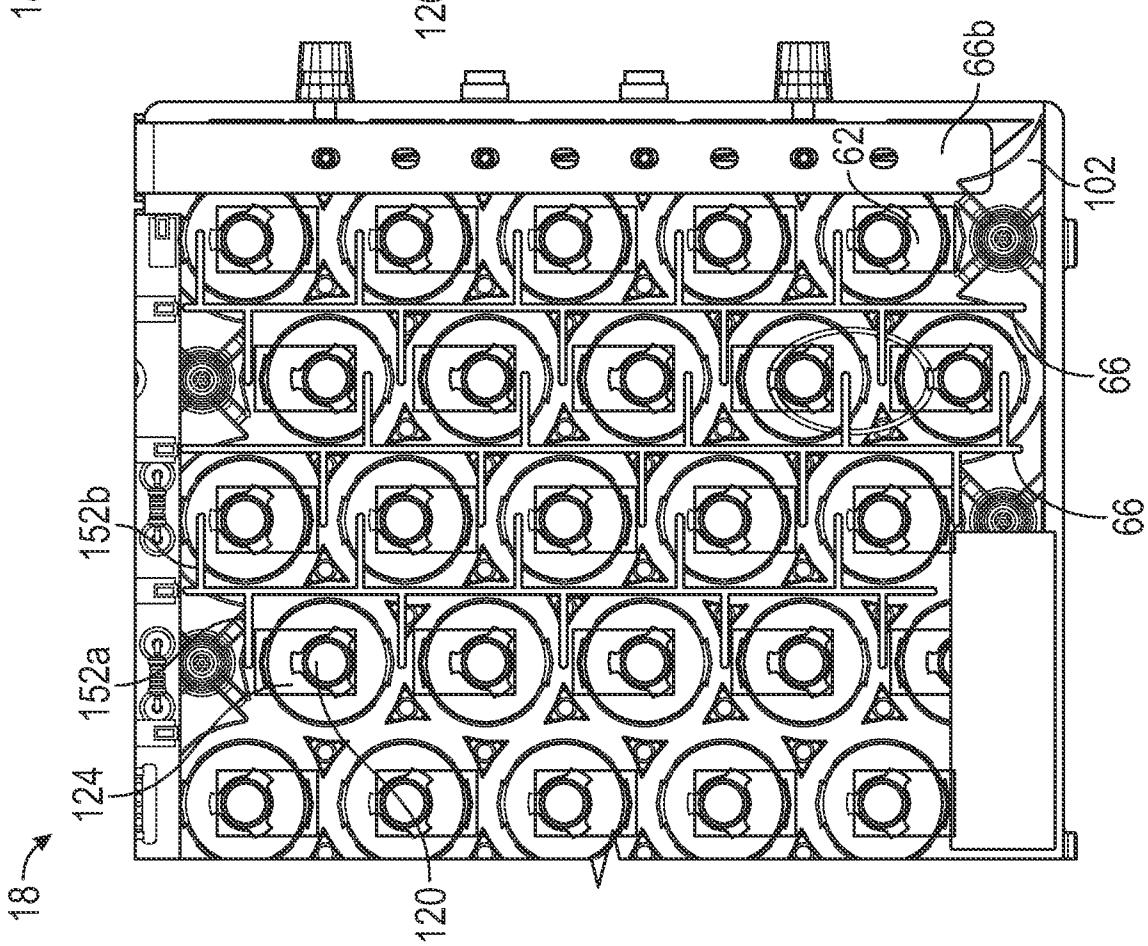

66b
62
102
66
66
152b
152a
124
120
18

FIG. 23

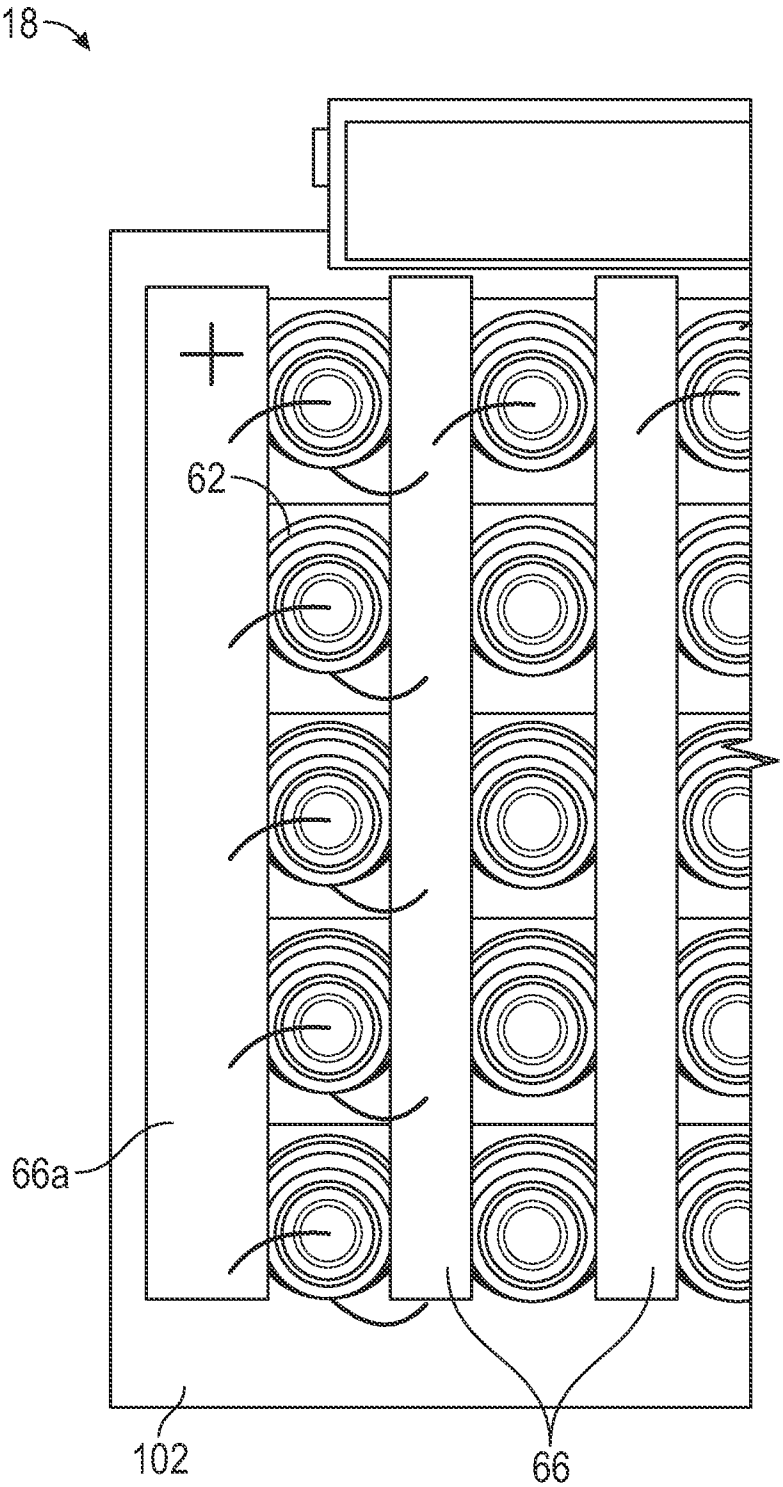


FIG. 25

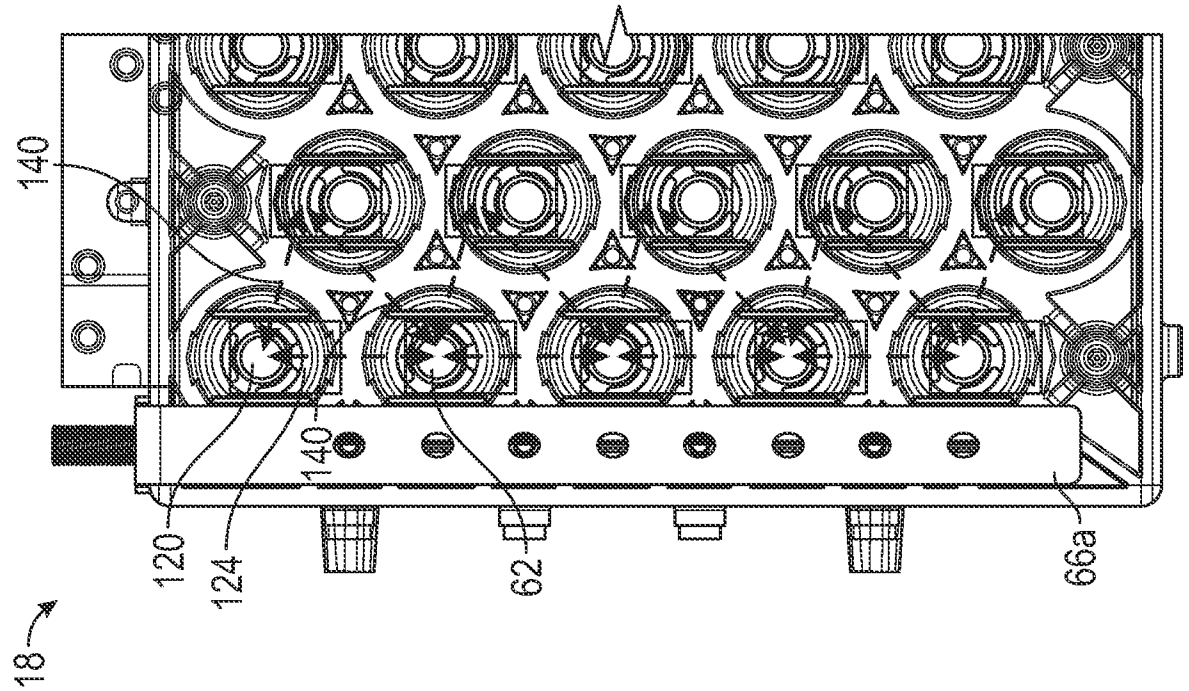


FIG. 27

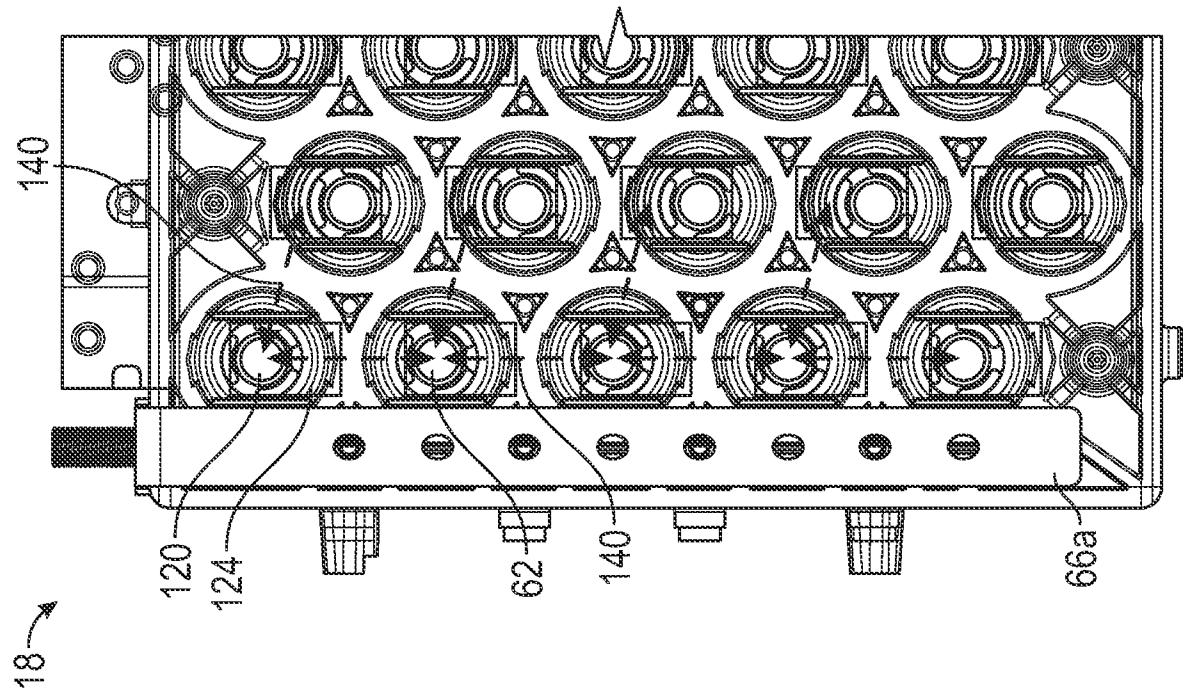


FIG. 26

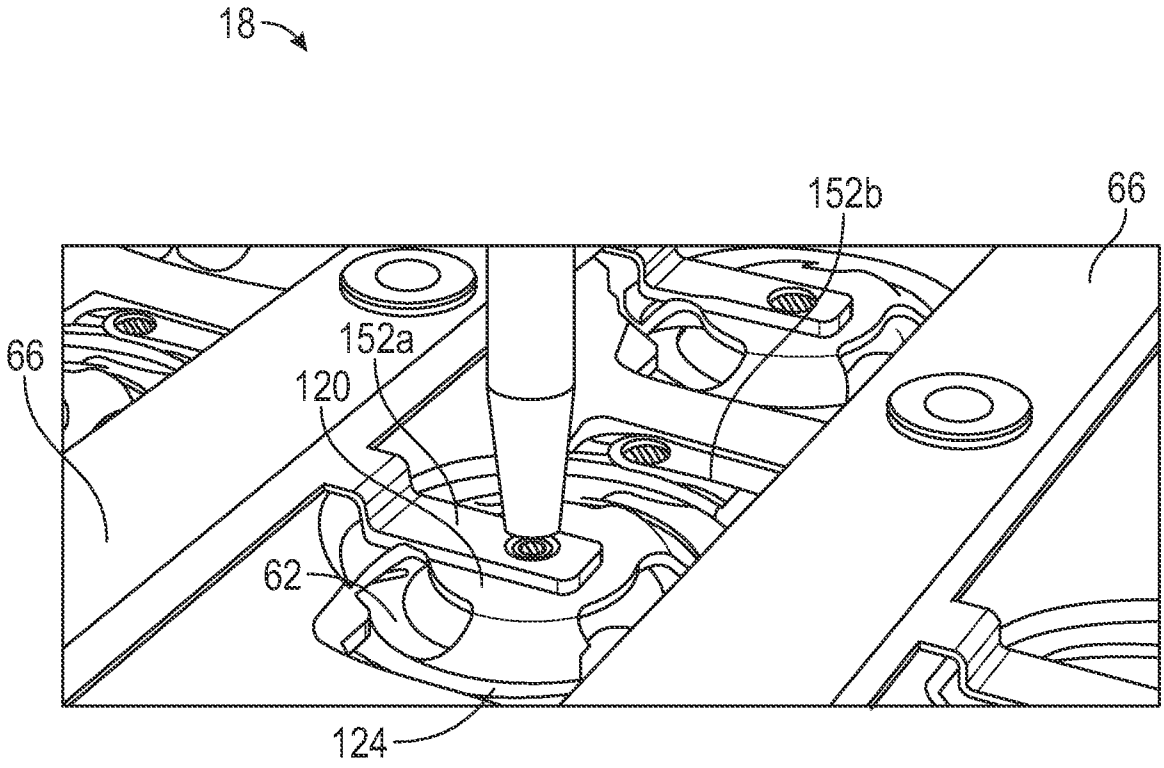


FIG. 28

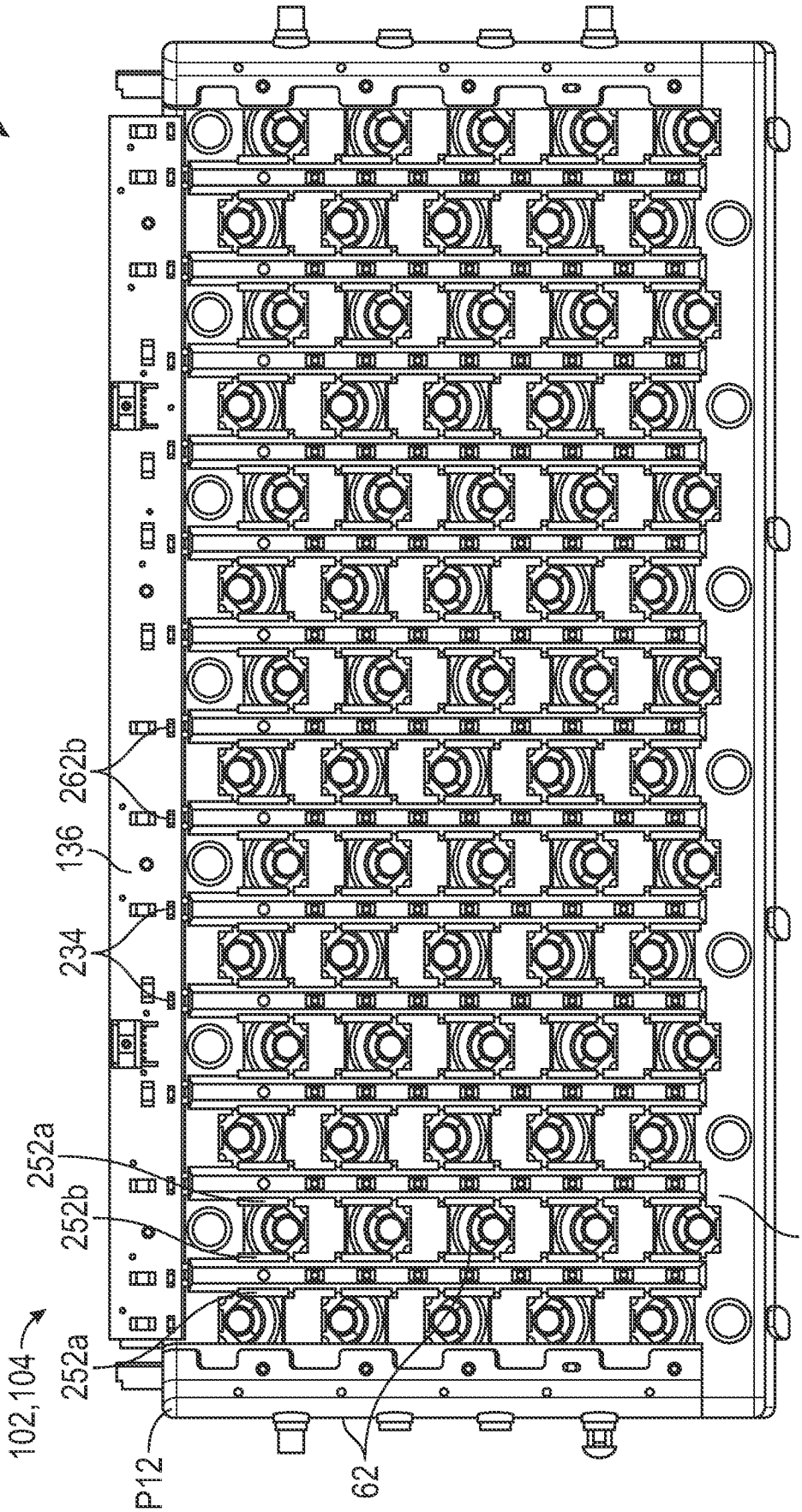


FIG. 29

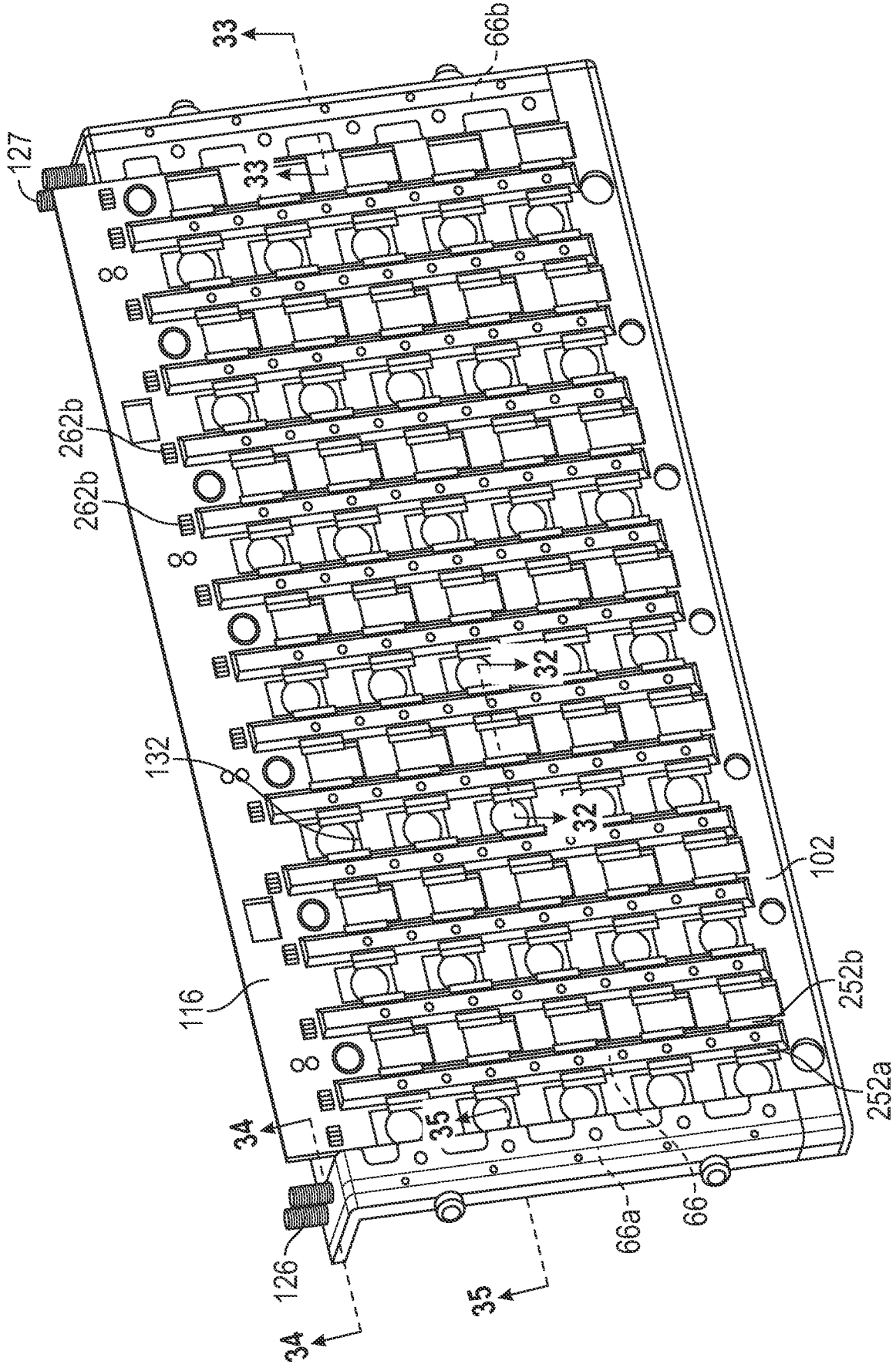

33
66b
127
33
262b
262b
32
132
32
102
116
252b
252a
34
35
66a
66
126
35
34

FIG. 30

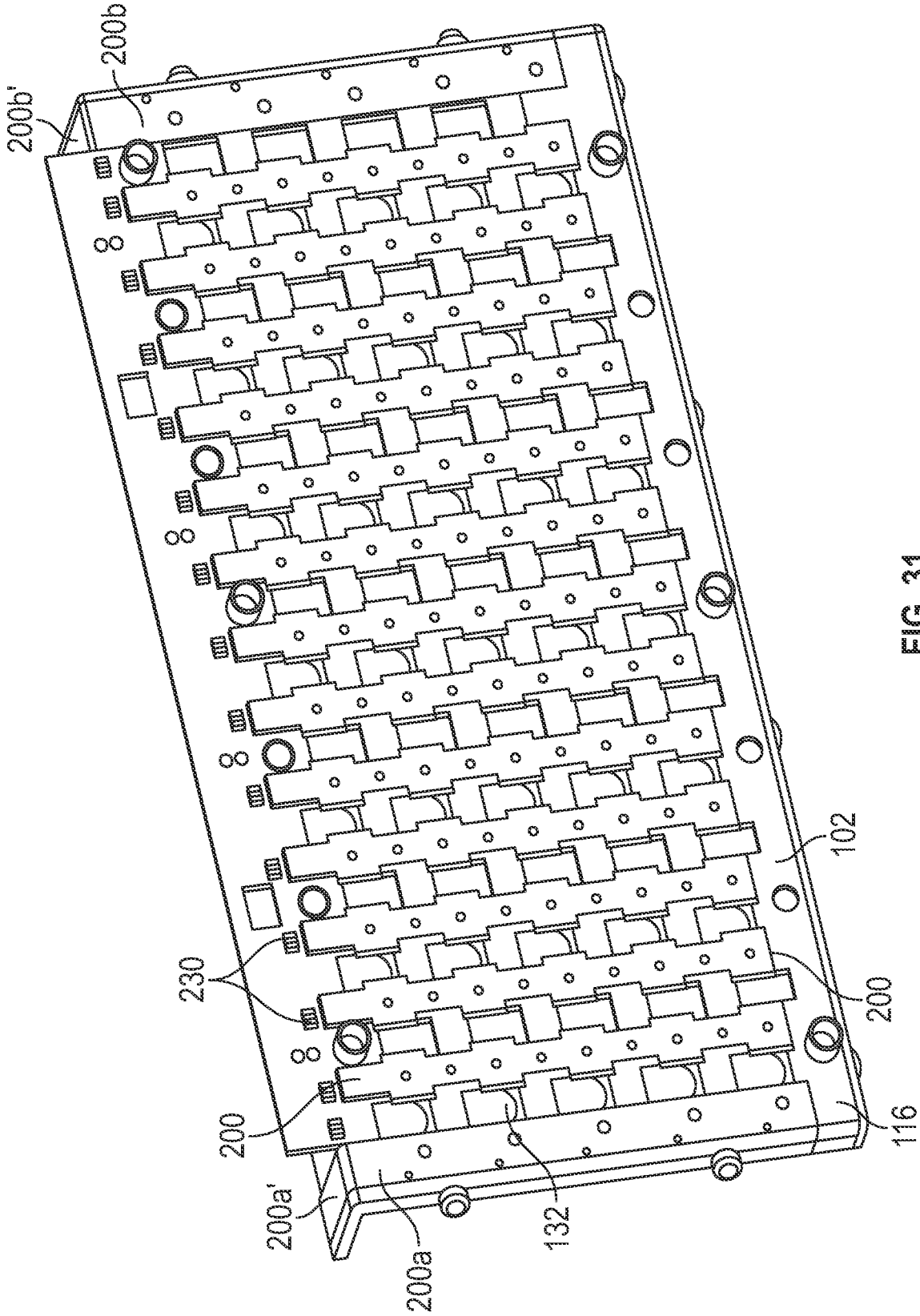


FIG. 31

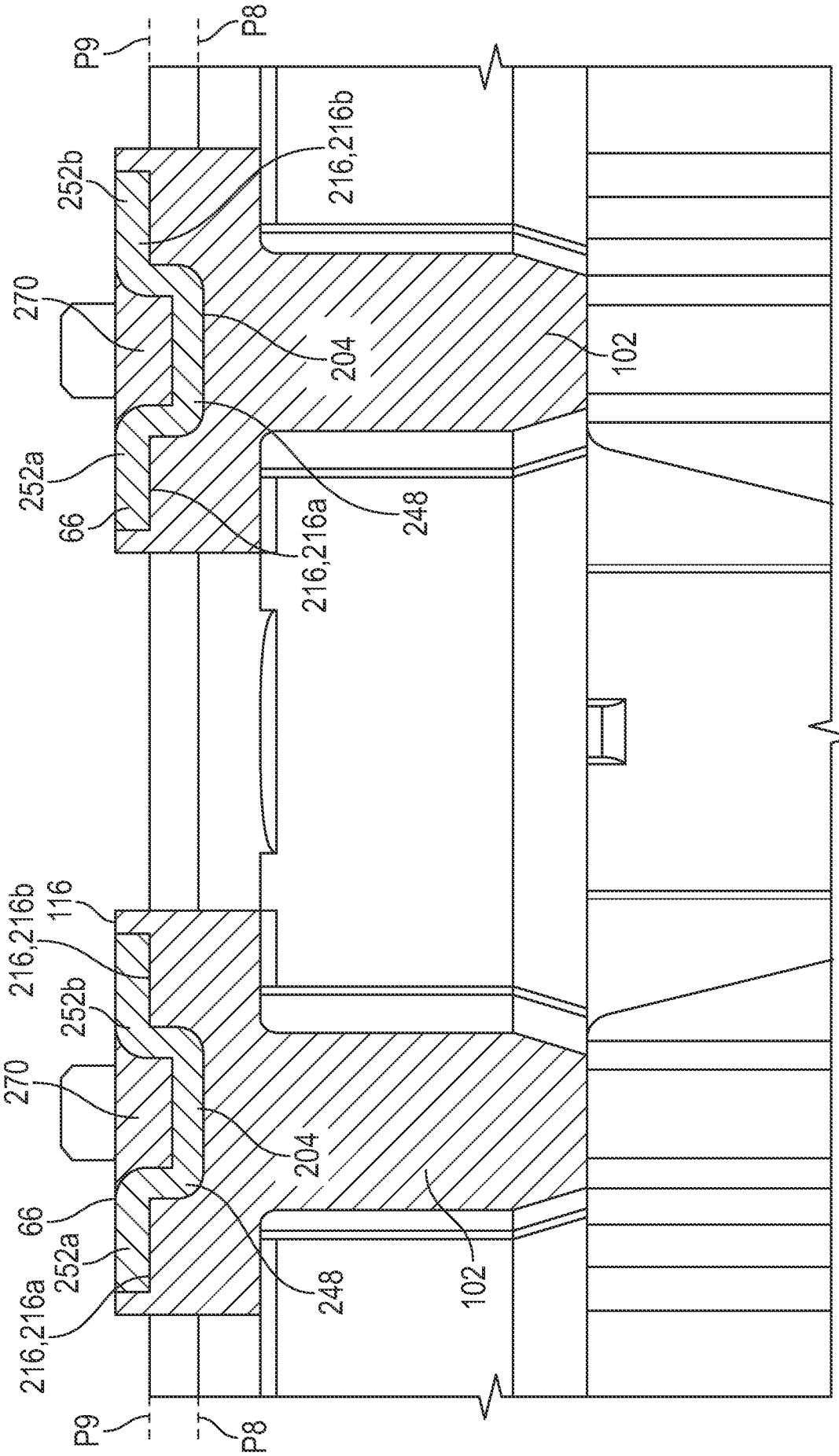


FIG. 32

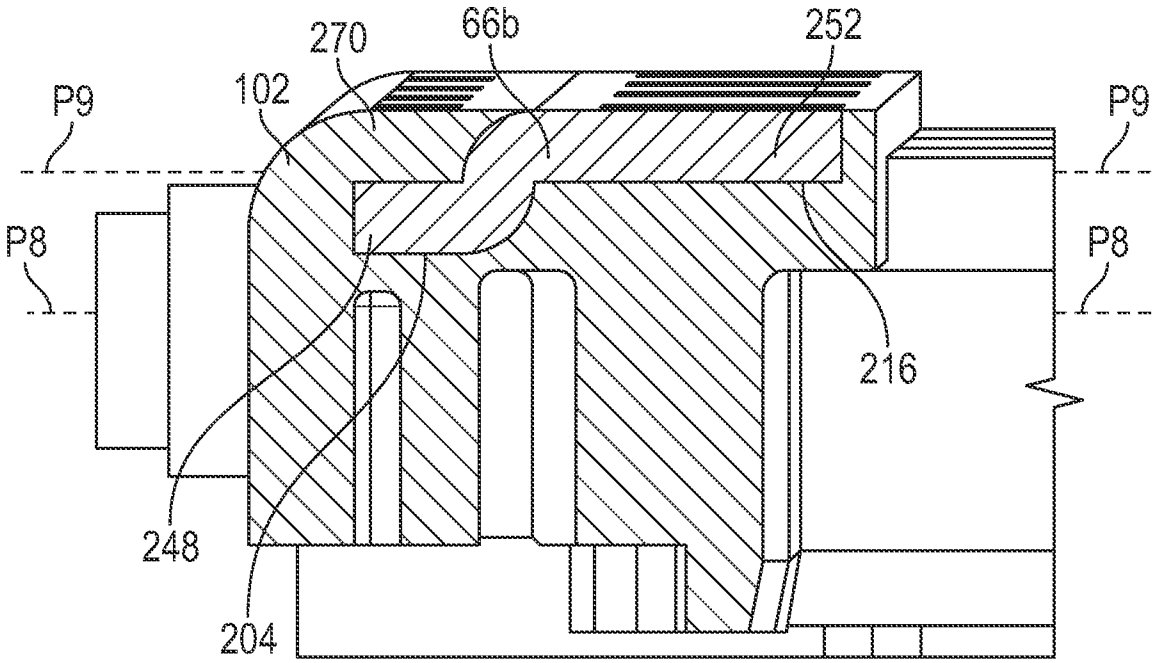


FIG. 33

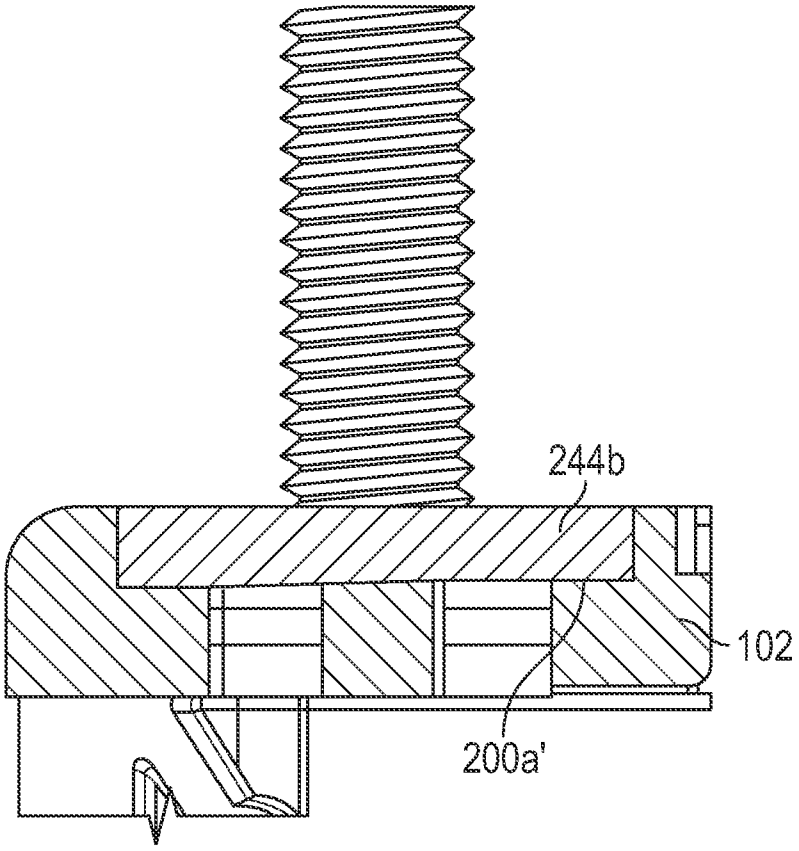


FIG. 34

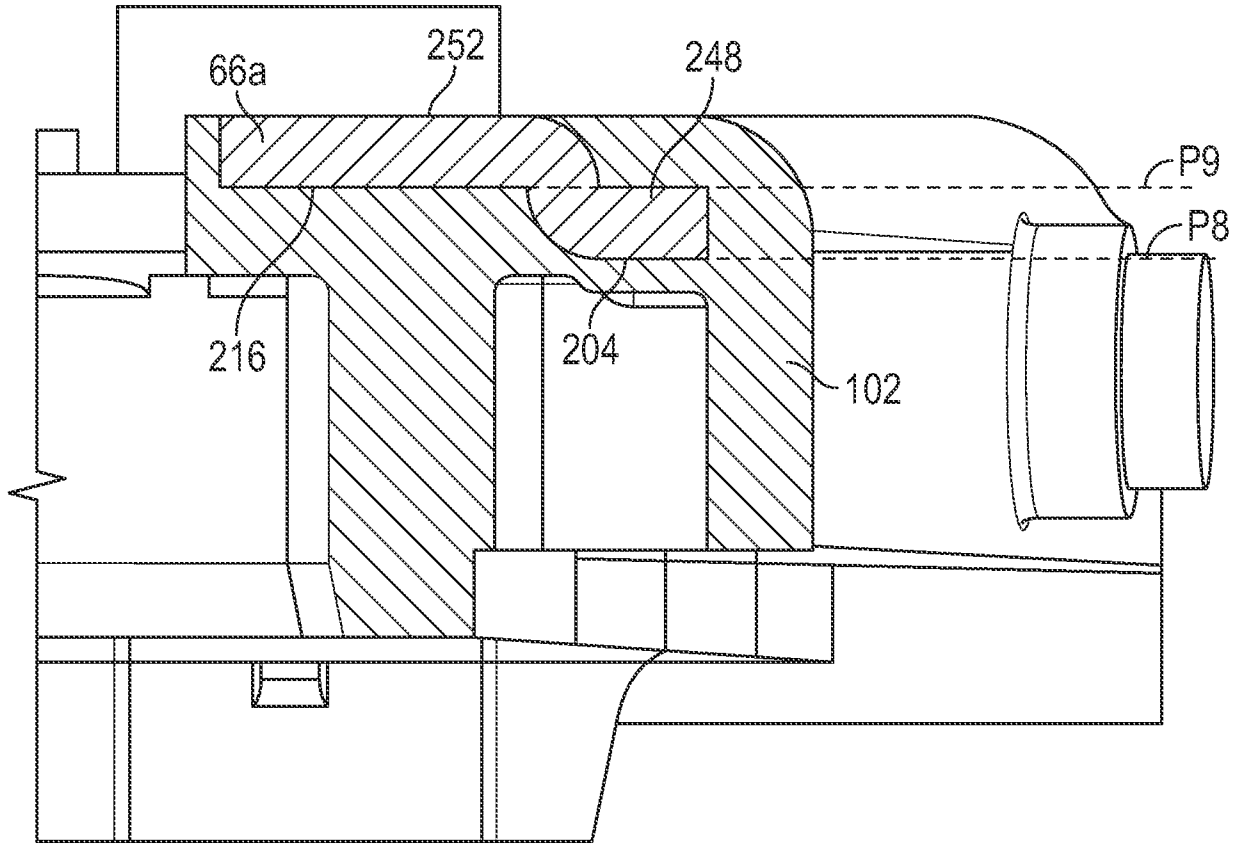

66a
252
248
P9
P8
216
204
102

FIG. 35

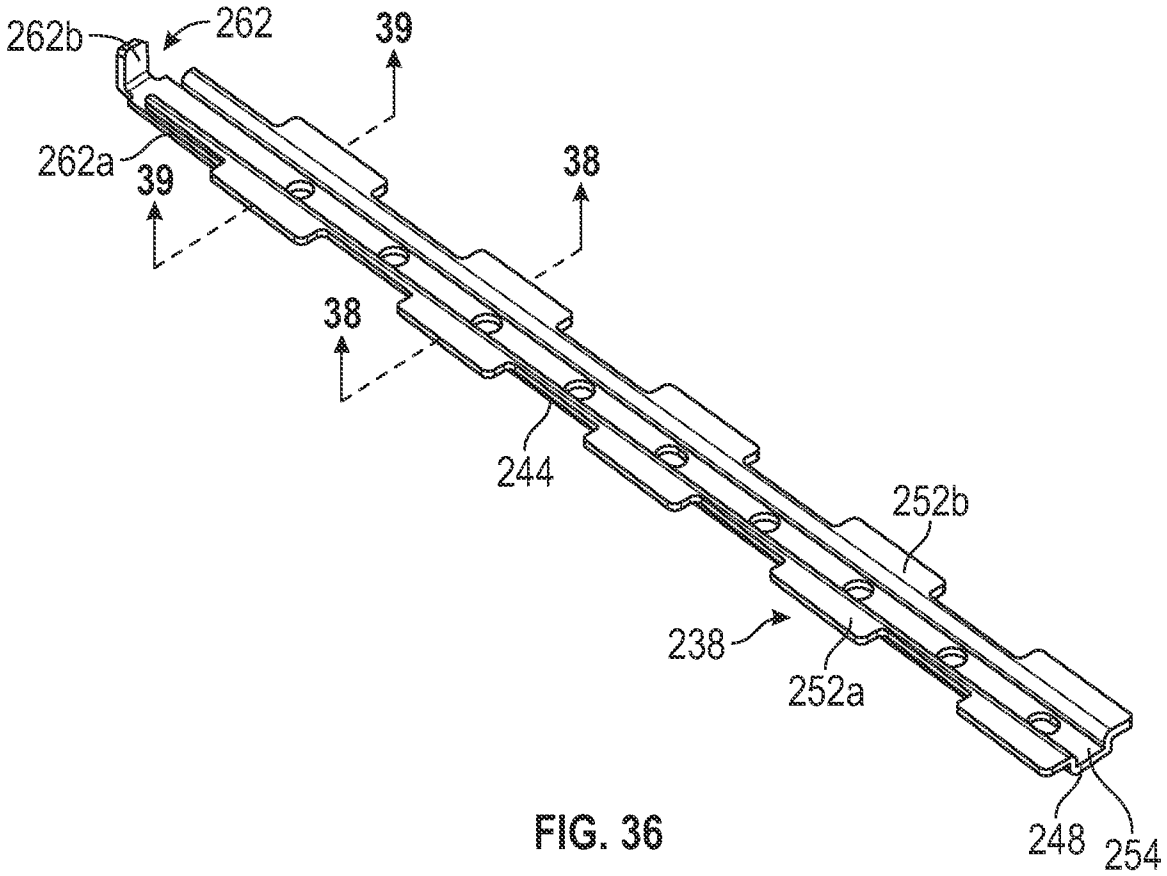

262b
262
39
262a
39
38
38
244
252b
238
252a
248
254

FIG. 36

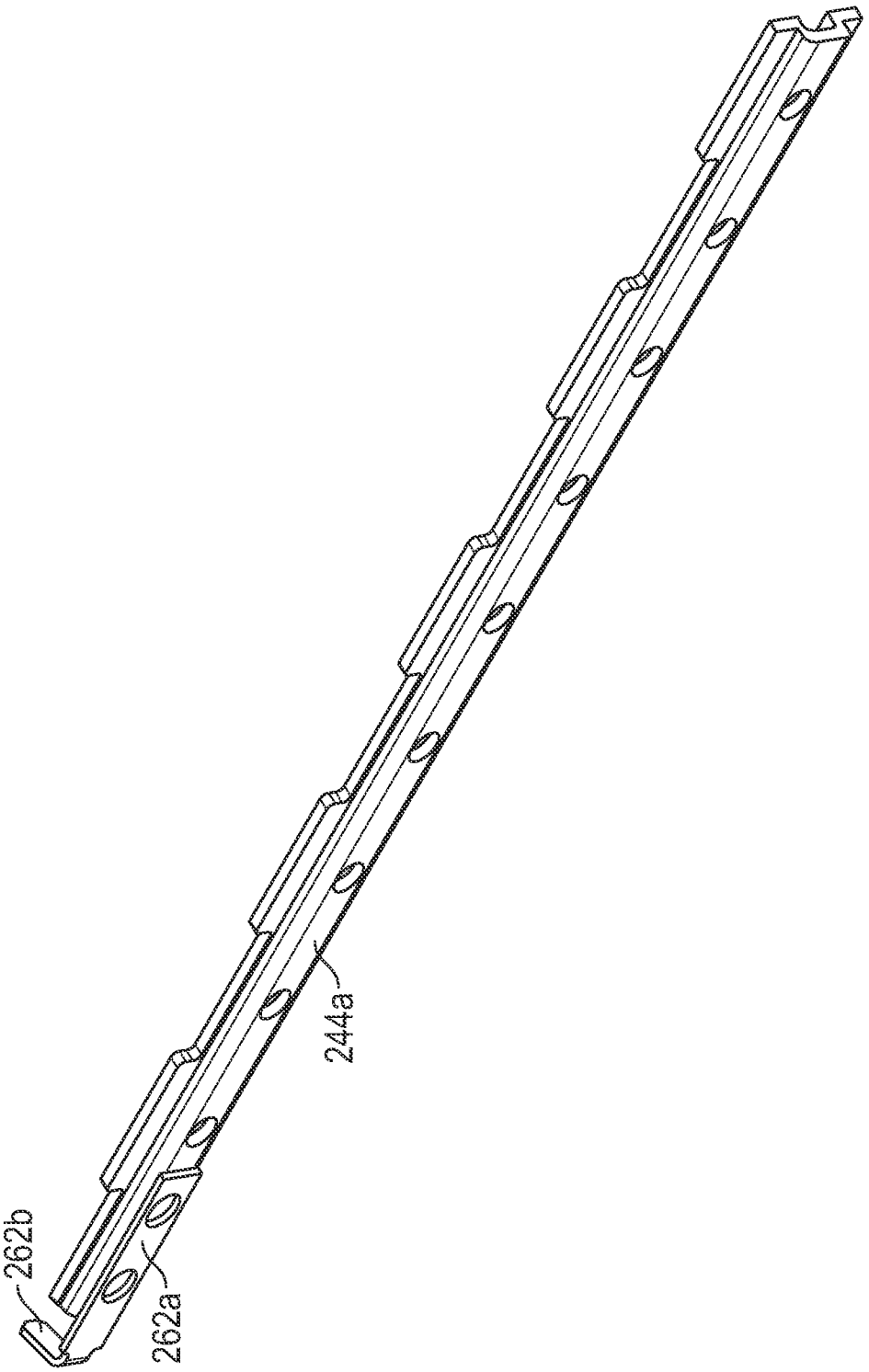


FIG. 37

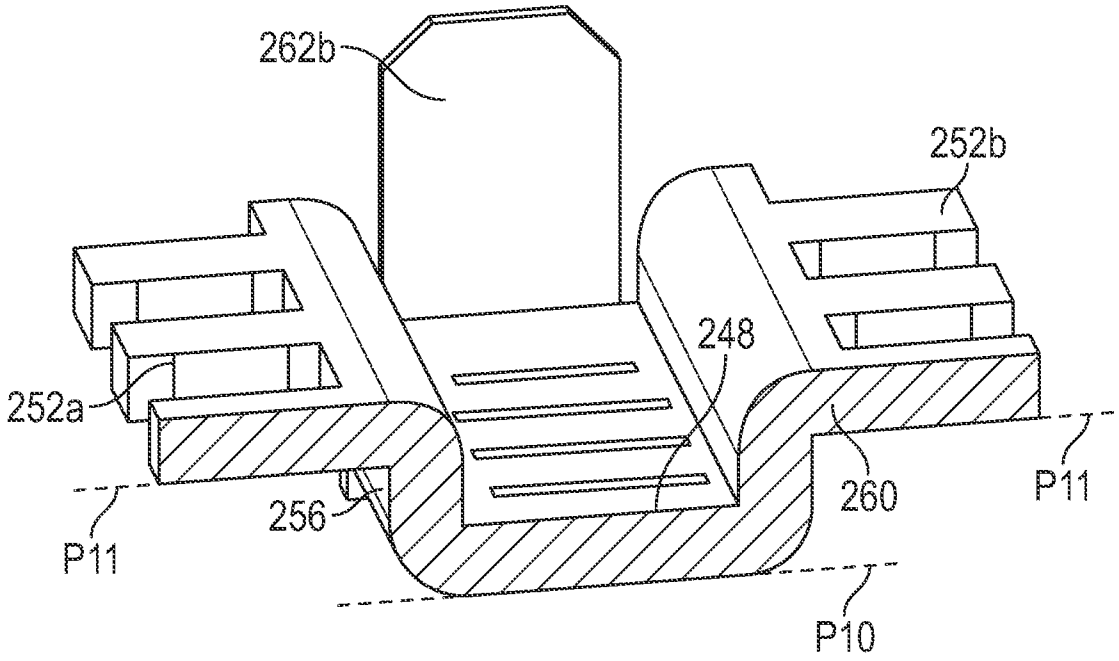

262b
252b
248
252a
256
260
P11
P11
P10

FIG. 38

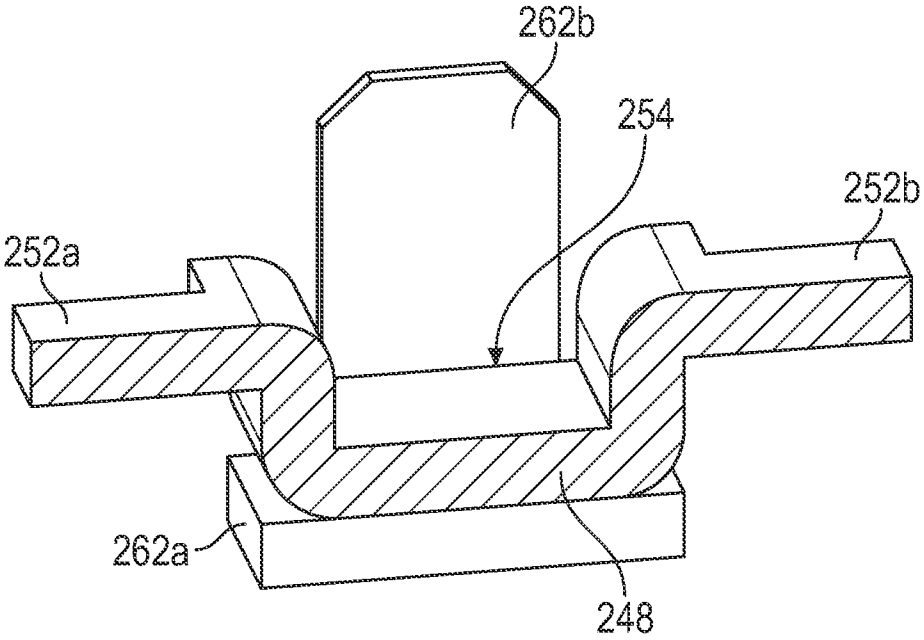

262b
254
252b
252a
262a
248

FIG. 39

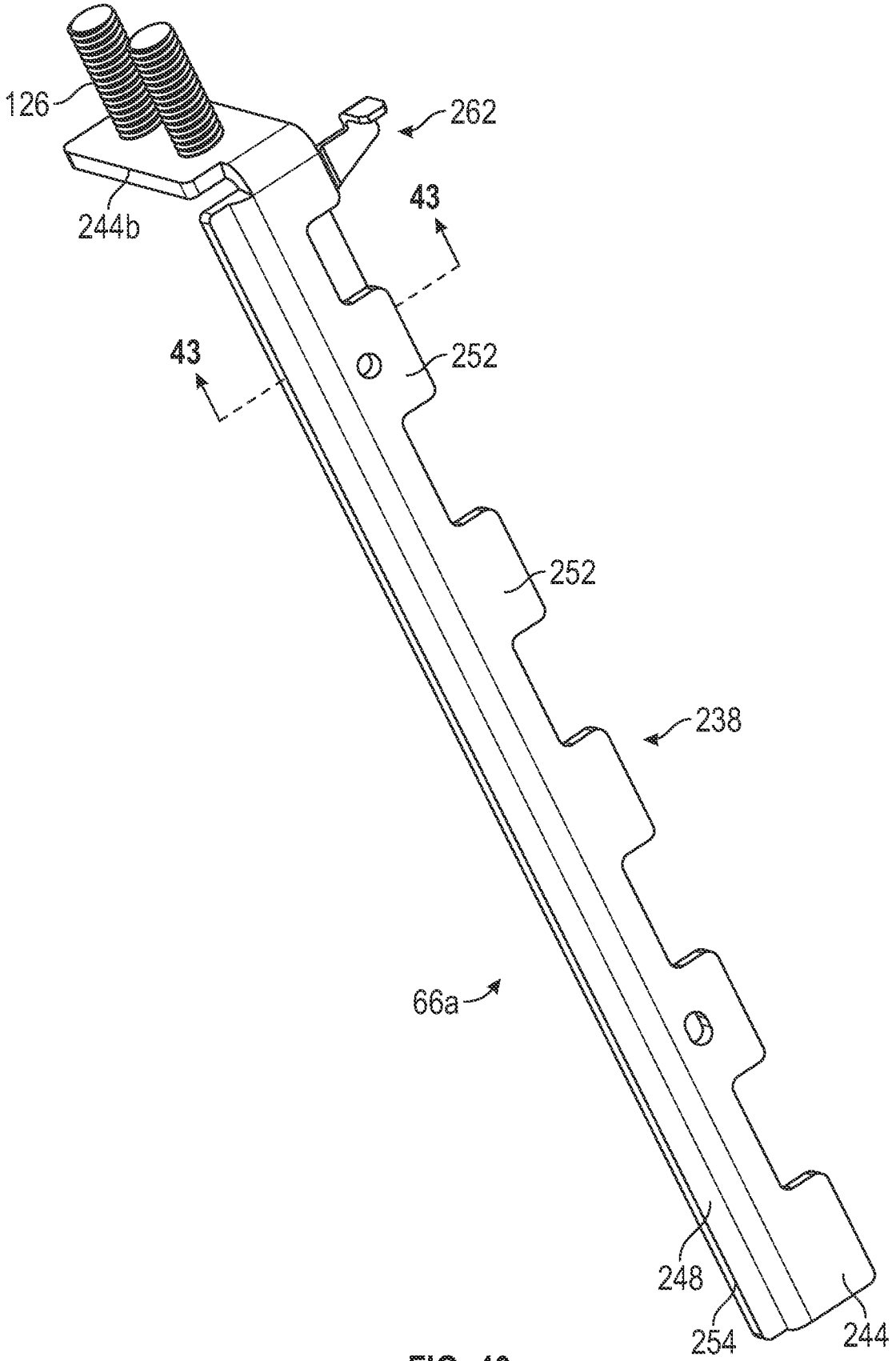


FIG. 40

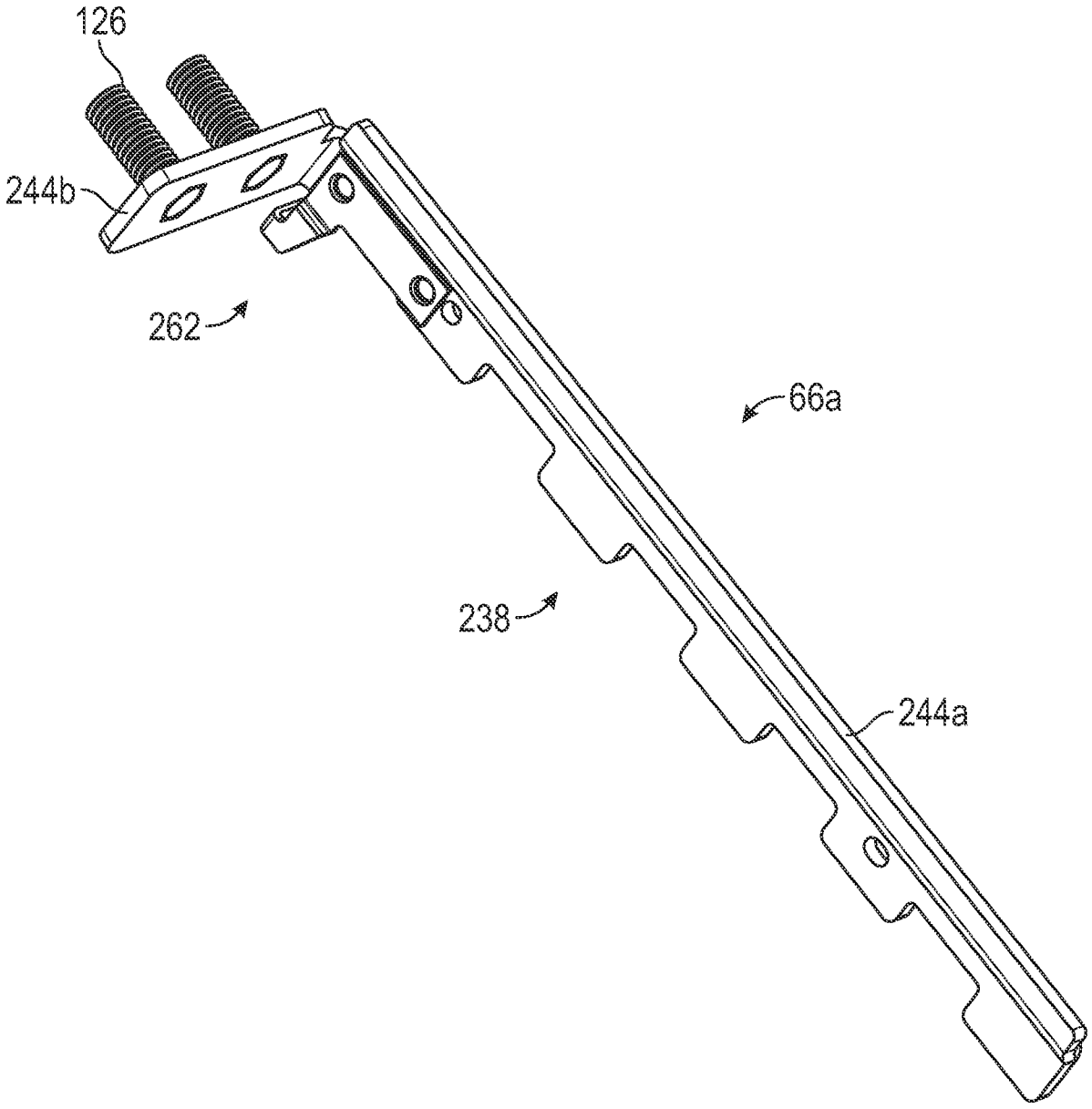


FIG. 41

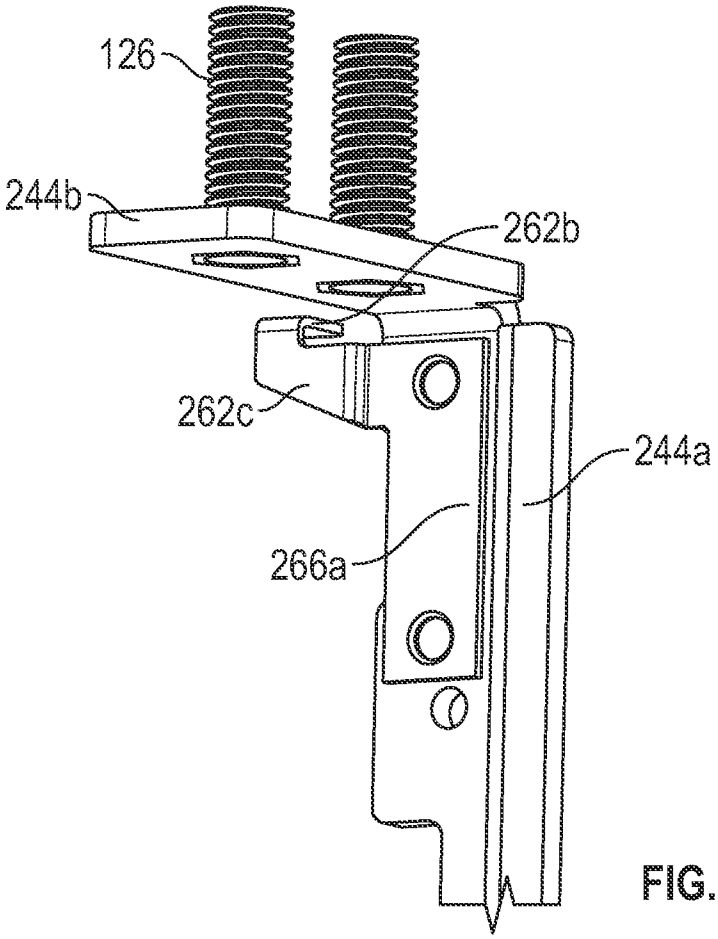


FIG. 42

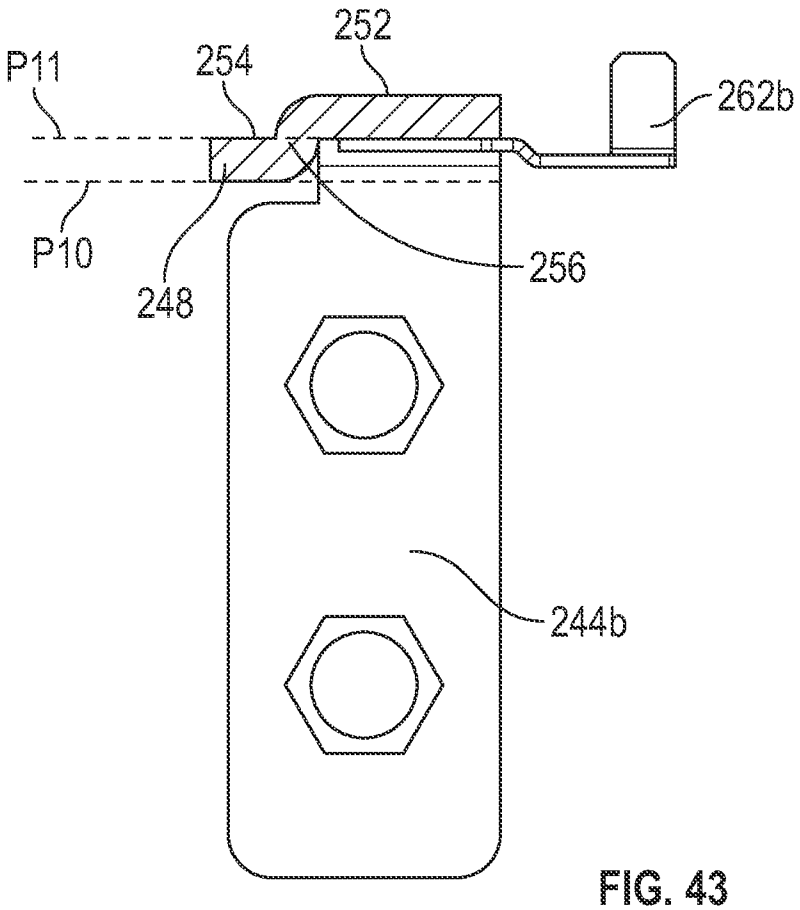


FIG. 43

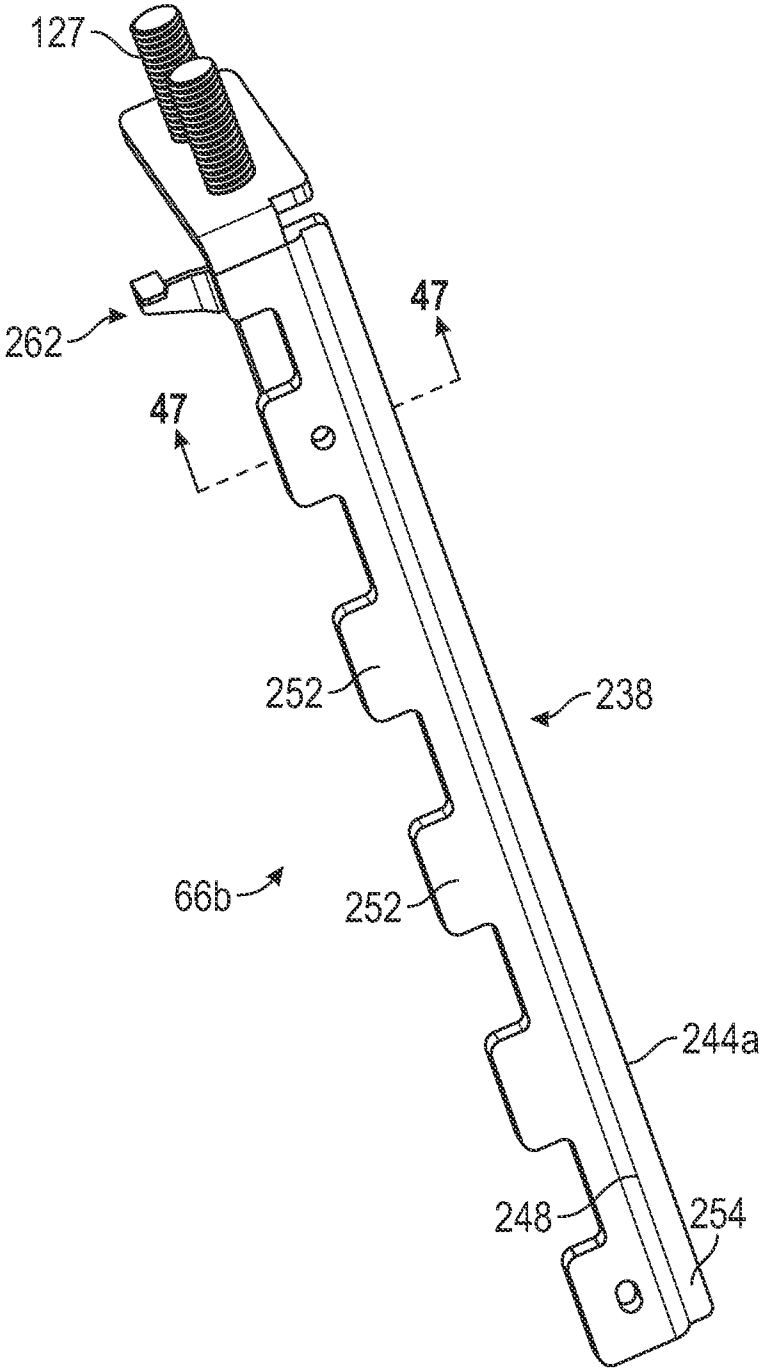

127
262
47
47
252
238
66b
252
244a
248
254

FIG. 44

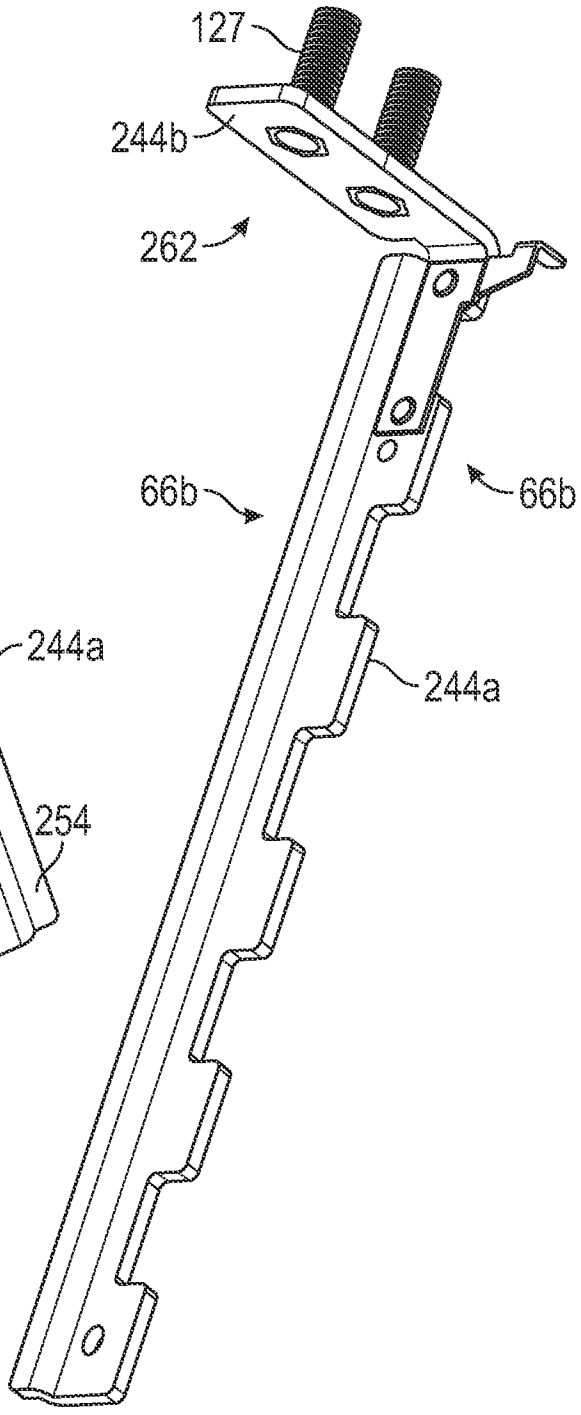

127
244b
262
66b
66b
244a

FIG. 45

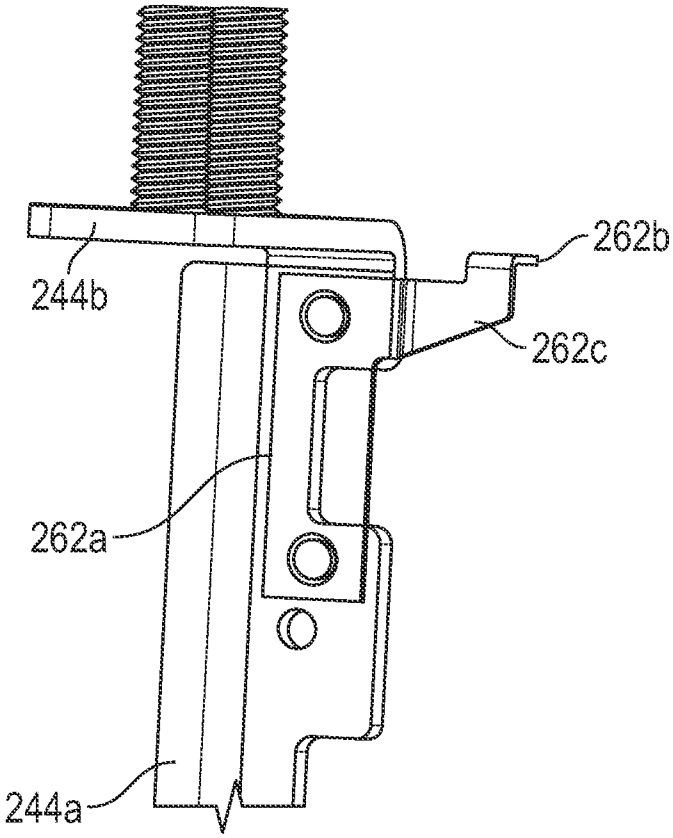


FIG. 46

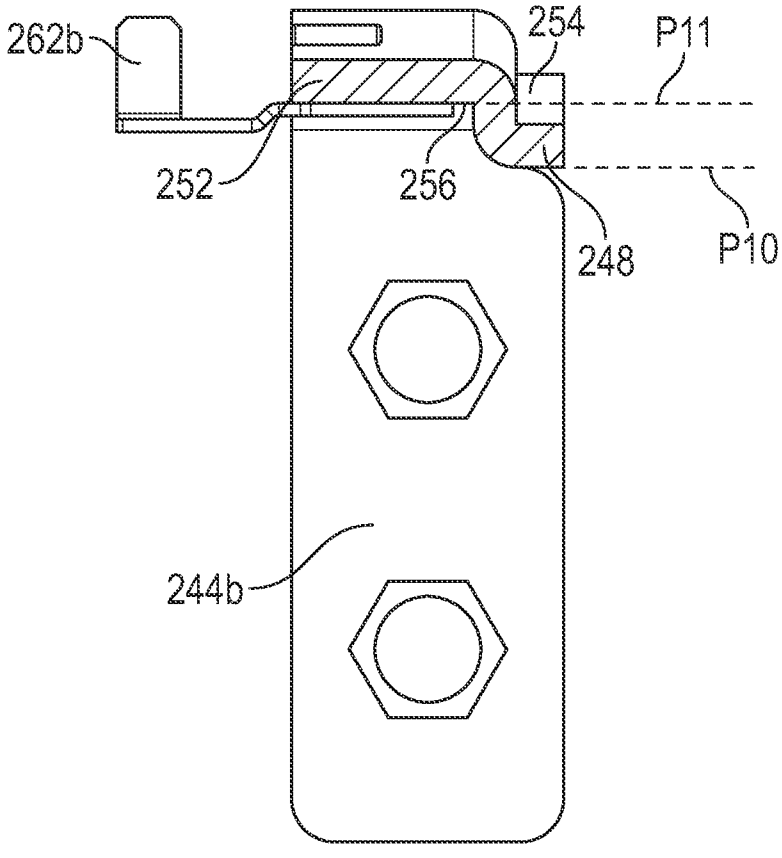


FIG. 47

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2022/042991

A. CLASSIFICATION OF SUBJECT MATTER

H01M 50/503(2021.01)i; **H01M 50/514**(2021.01)i; **H01M 50/519**(2021.01)i; **H01M 50/521**(2021.01)i; **H01M 50/543**(2021.01)i; **H01M 50/289**(2021.01)i; **H01M 50/107**(2021.01)i; **H01M 50/213**(2021.01)i; **H01M 50/569**(2021.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01M 50/503(2021.01); H01M 10/04(2006.01); H01M 2/10(2006.01); H01M 2/14(2006.01); H01M 2/20(2006.01); H01R 25/16(2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: battery pack, bus bar, molding, fingers

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2021-0091351 A1 (LG CHEM, LTD.) 25 March 2021 (2021-03-25) paragraphs [45]-[70] and figures 1-6	1-7
A		8-19
Y	US 2017-0256769 A1 (ATIEVA, INC.) 07 September 2017 (2017-09-07) paragraphs [41], [49] and figures 3, 7	1-7
Y	US 2020-0259154 A1 (ATIEVA, INC.) 13 August 2020 (2020-08-13) paragraphs [38], [41] and figures 7A, 7D	1-7
A	CN 209401936 U (GUANGZHOU XPENG AUTOMOBILE TECHNOLOGY CO., LTD.) 17 September 2019 (2019-09-17) the whole document	1-19

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
03 January 2023	**04 January 2023**

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office **189 Cheongsa-ro, Seo-gu, Daejeon** **35208, Republic of Korea**	**JANG, Gi Jeong**
Facsimile No. **+82-42-481-8578**	Telephone No. **+82-42-481-8364**

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2022/042991

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2020-0227699 A1 (PANASONIC INTELLECTUAL PROPERTY MANAGEMENT CO., LTD.) 16 July 2020 (2020-07-16) the whole document	1-19

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/US2022/042991

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		JP WO2019-044724 A1	24 September 2020
		US 11469467 B2	11 October 2022
		WO 2019-044724 A1	07 March 2019