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(54) **LOAD BANK APPARATUS**

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(73) Assignee: **ULB, L.L.C.**, Wixom, MI (US)

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Publication Classification

(51) **Int. Cl.**

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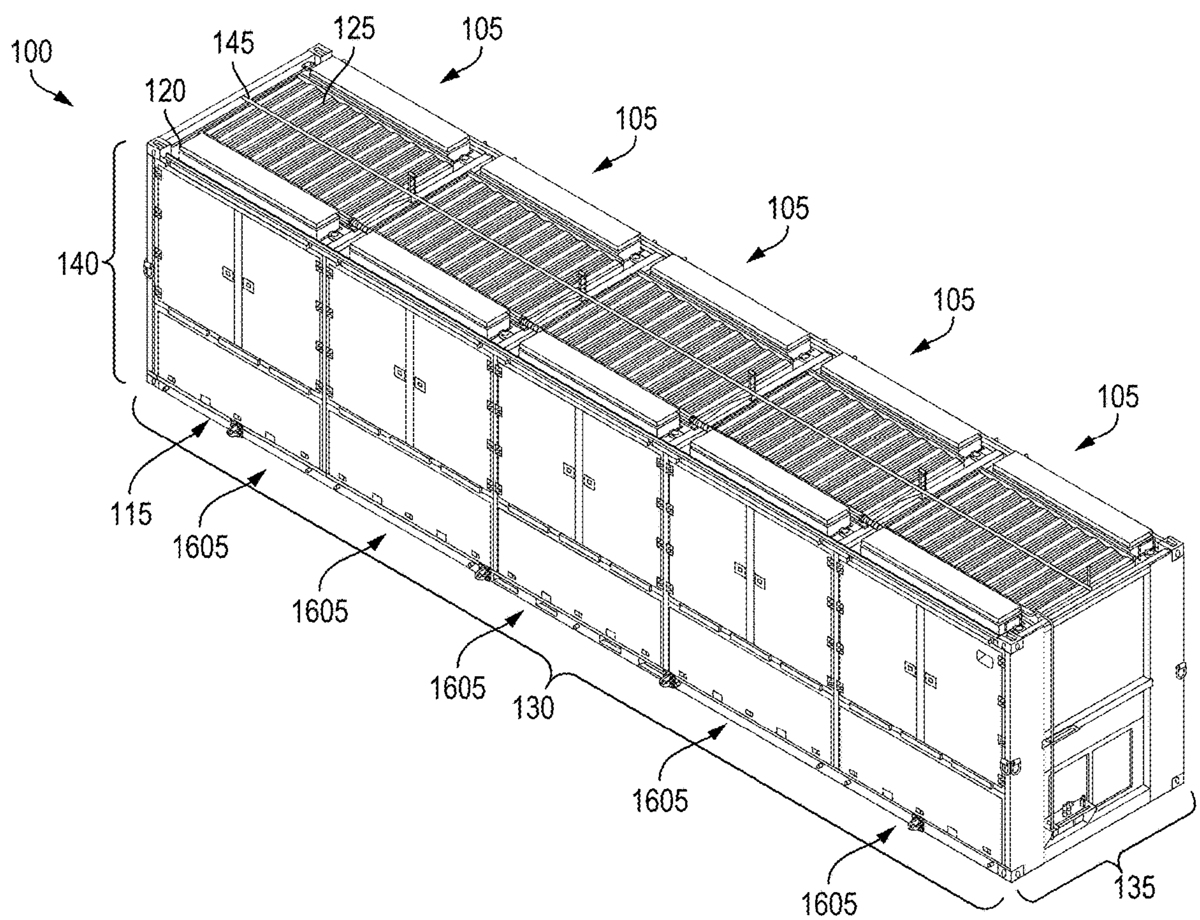
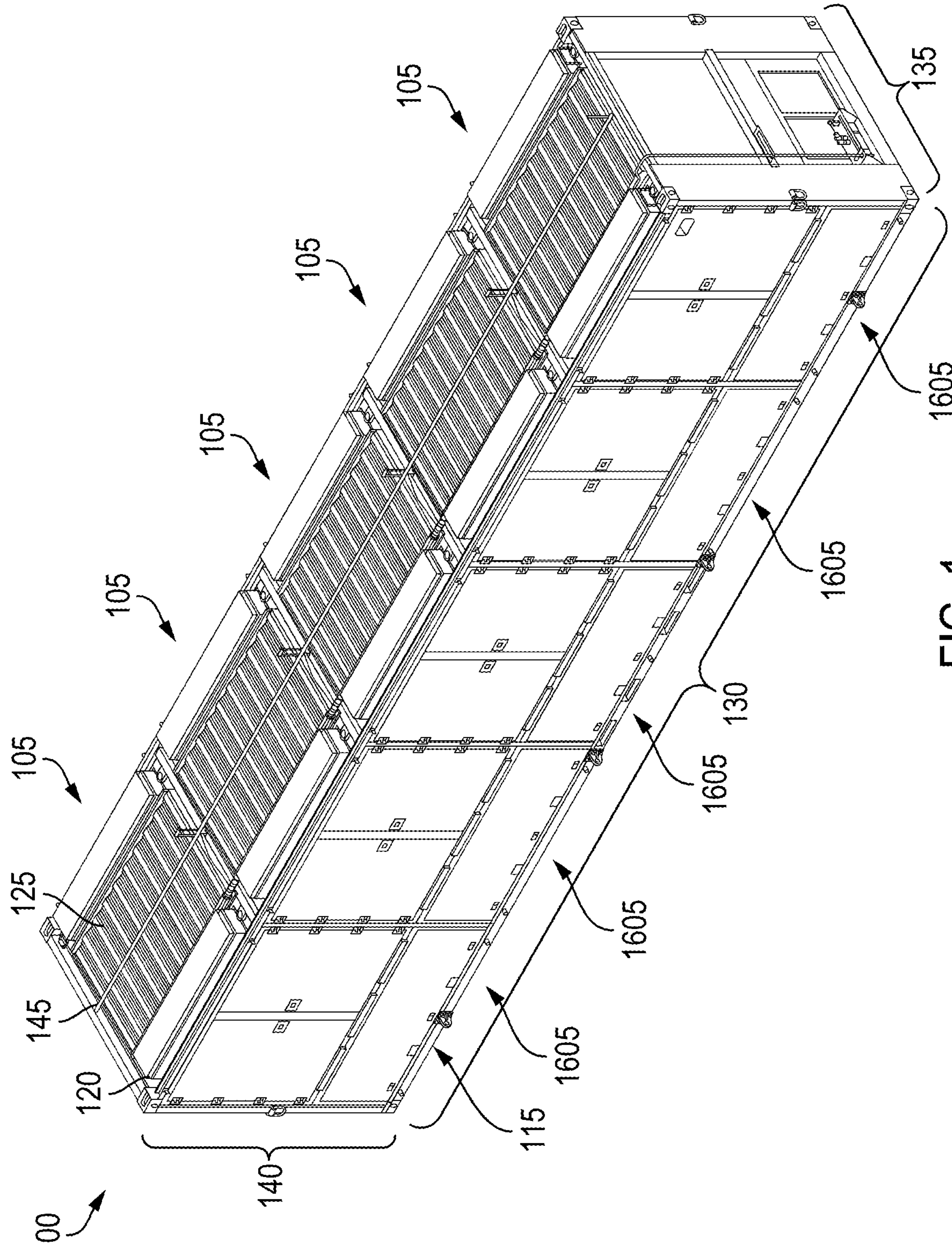
G01R 31/42	(2006.01)
H01C 1/022	(2006.01)
H01C 3/20	(2006.01)

(52) **U.S. Cl.**
CPC ***H01C 1/16*** (2013.01); ***G01R 31/42*** (2013.01); ***H01C 1/022*** (2013.01); ***H01C 3/20*** (2013.01)

(57) **ABSTRACT**

An apparatus can a load bank module configured to electrically couple with at least one other load bank module. The load bank module and the at least one other load bank module can be further configured to electrically couple to a power source to dissipate power received from the power source. The load bank module can include trays including resistive components to dissipate the power received from the power source at a voltage level of the power source. A resistive component of the resistive components can include a coil, the coil can extending between a first end of the resistive component and a second end of the resistive component opposite the first end of the resistive component to form three or more turns of the coil.





105
105
105
105
105
135
125
145
120
1605
1605
1605
1605
1605
130
115
140
100

FIG. 1

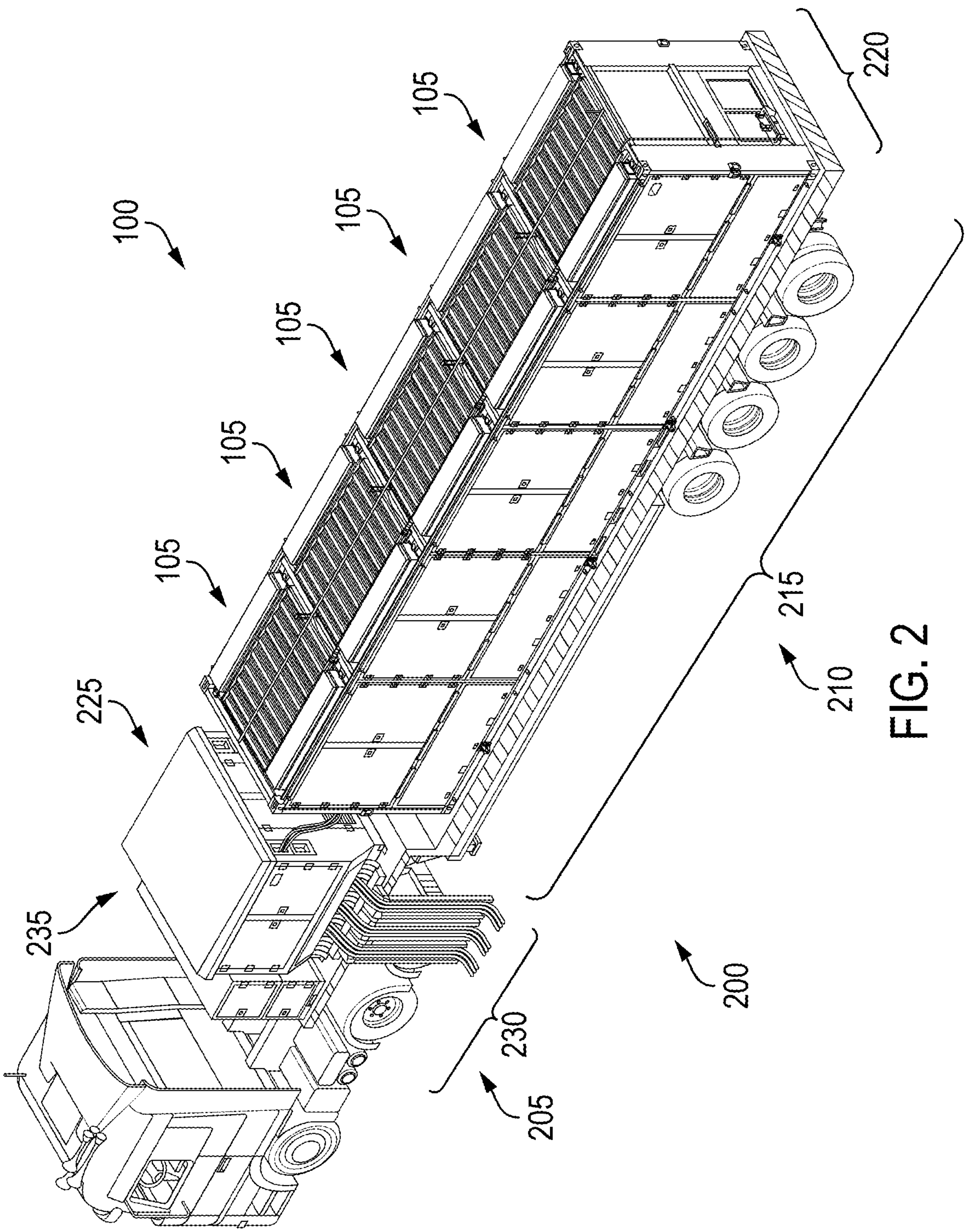


FIG. 2

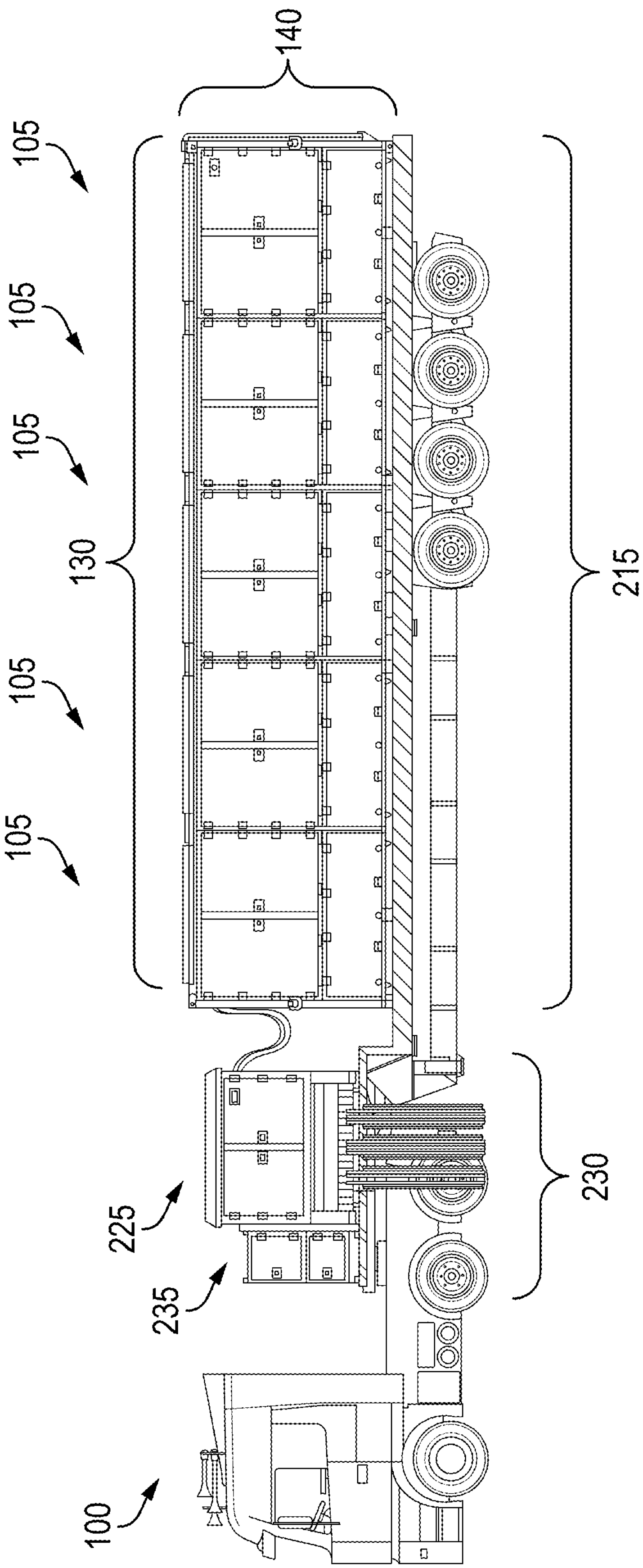


FIG. 3A

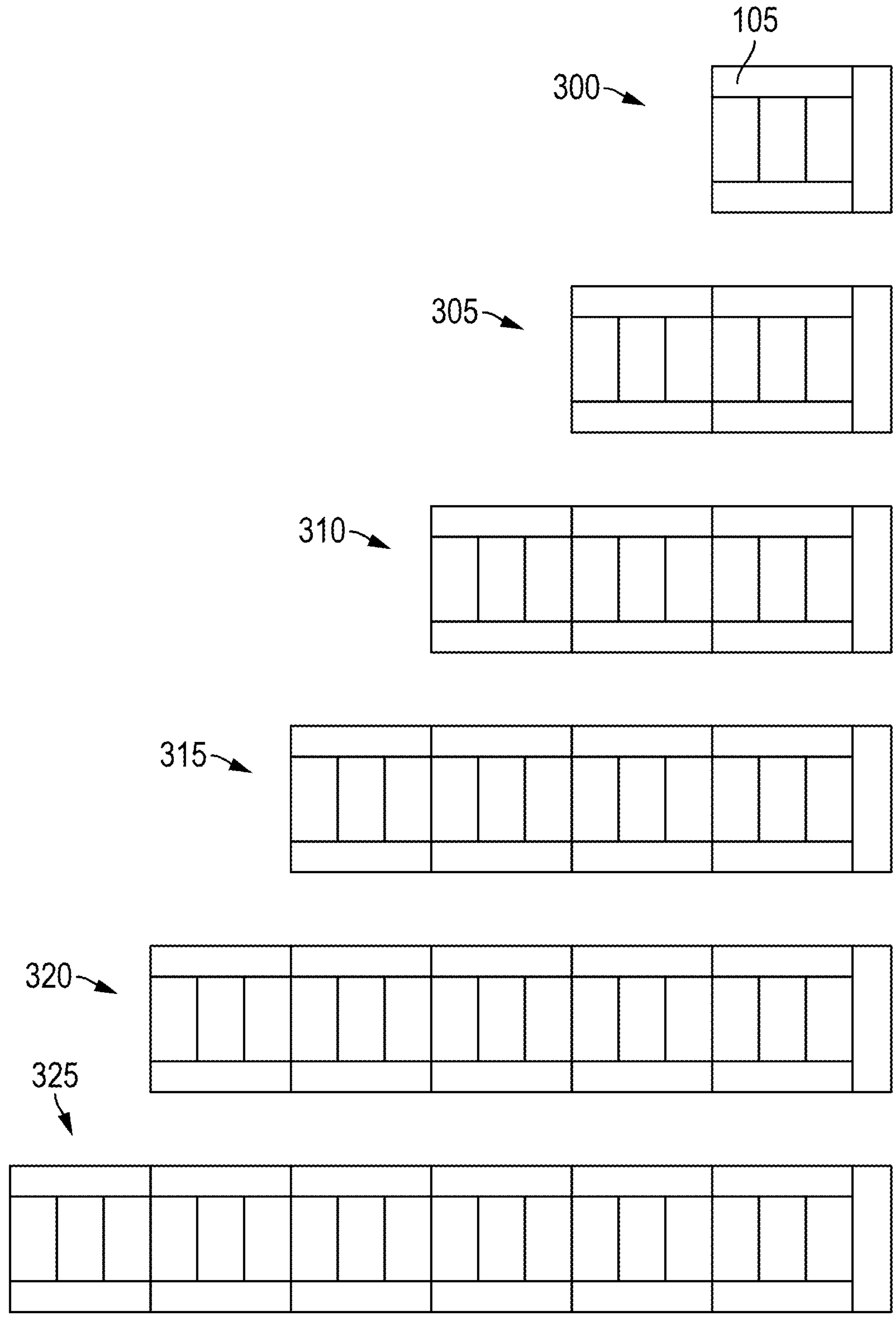


FIG. 3B

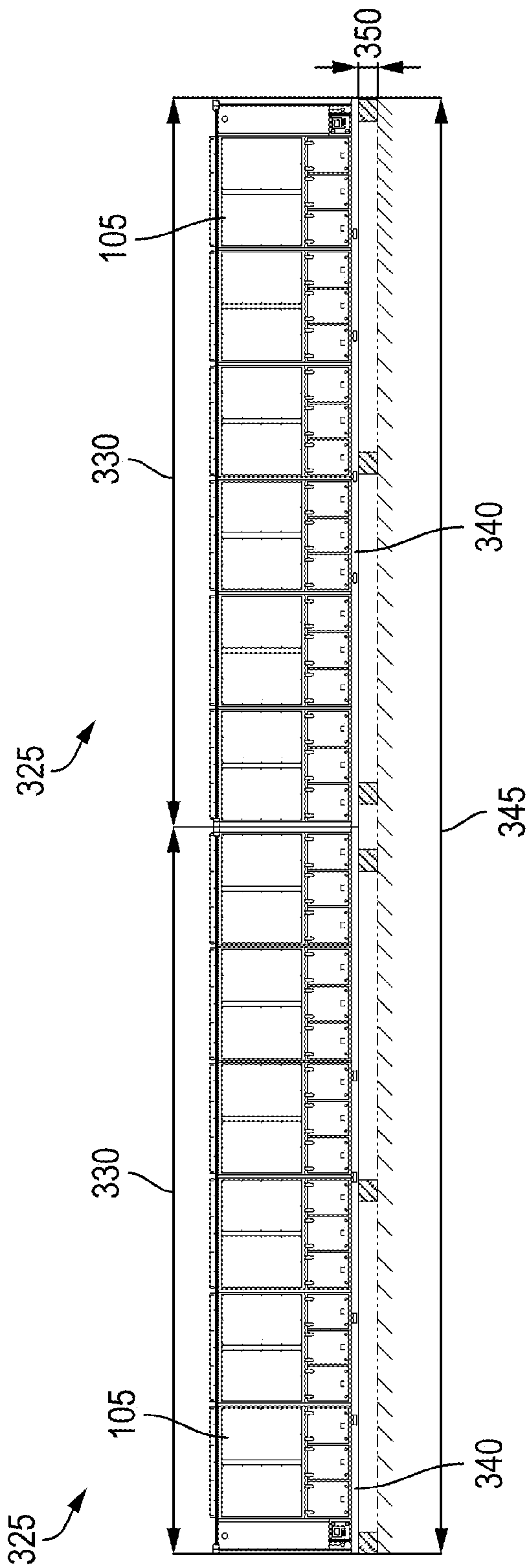


FIG. 3C

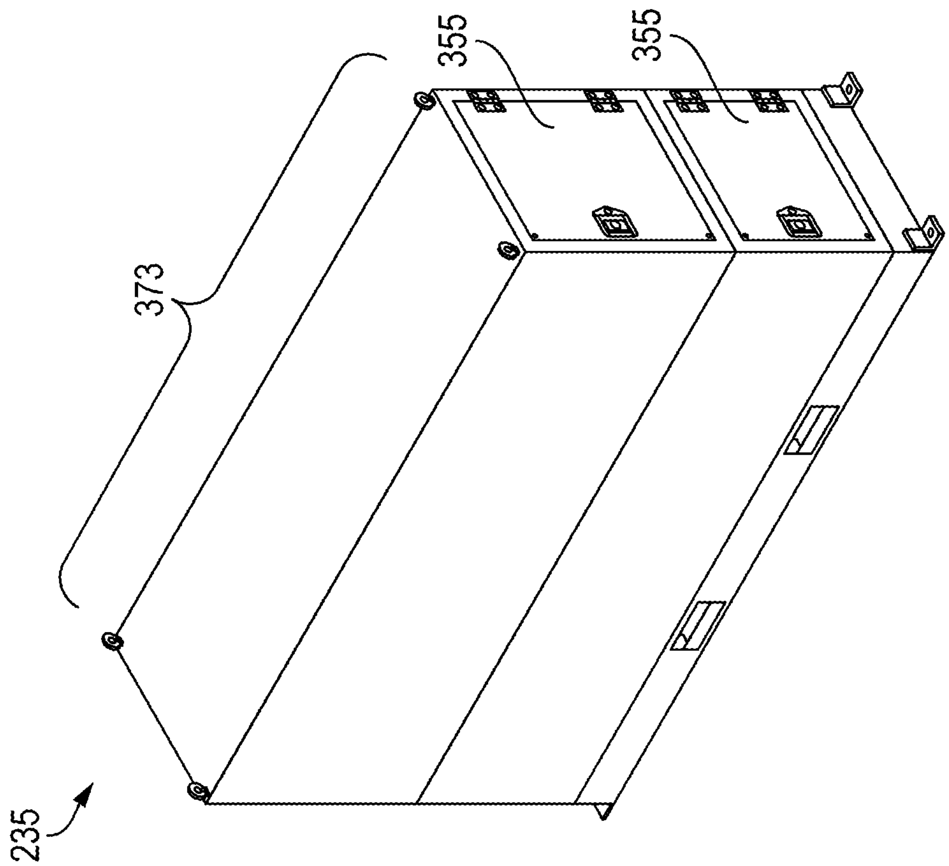


FIG. 3E

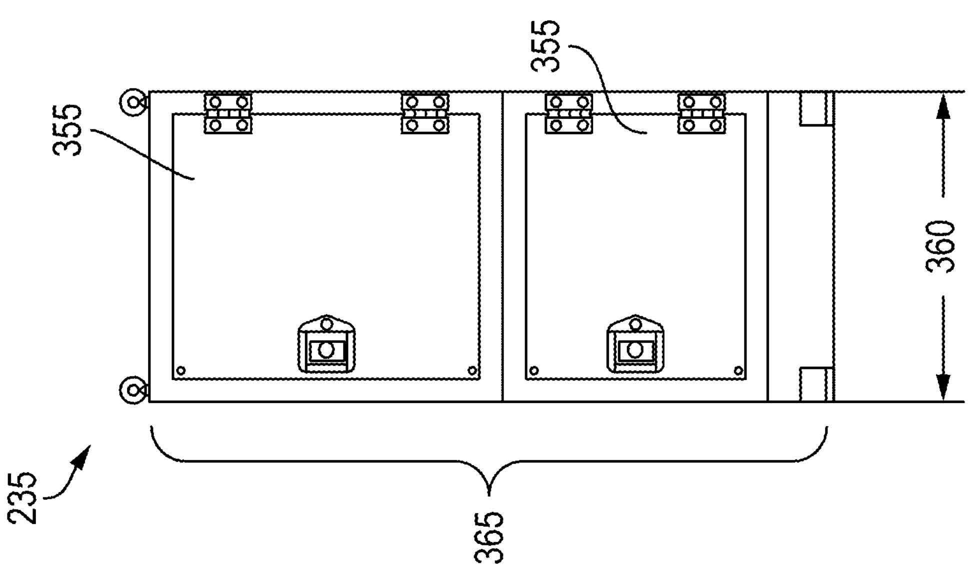


FIG. 3D

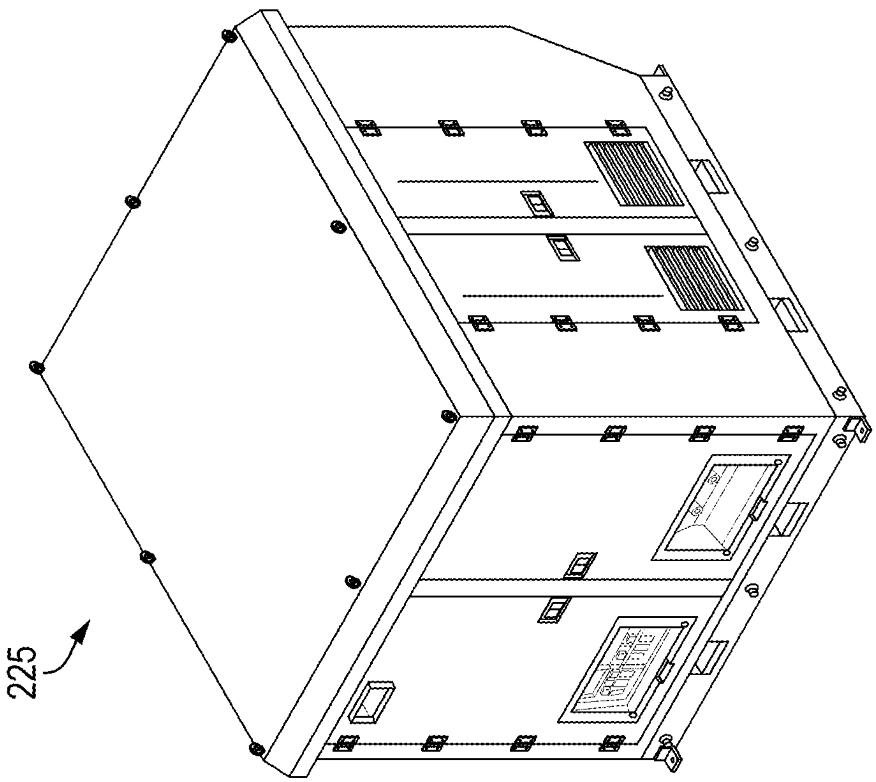


FIG. 3G

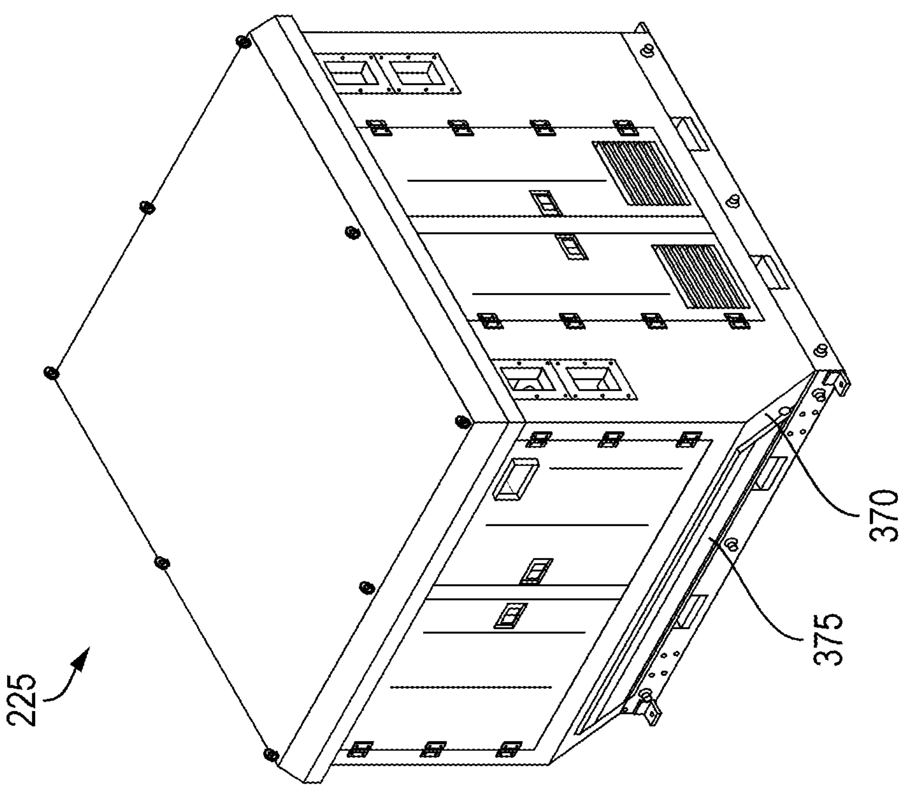


FIG. 3F

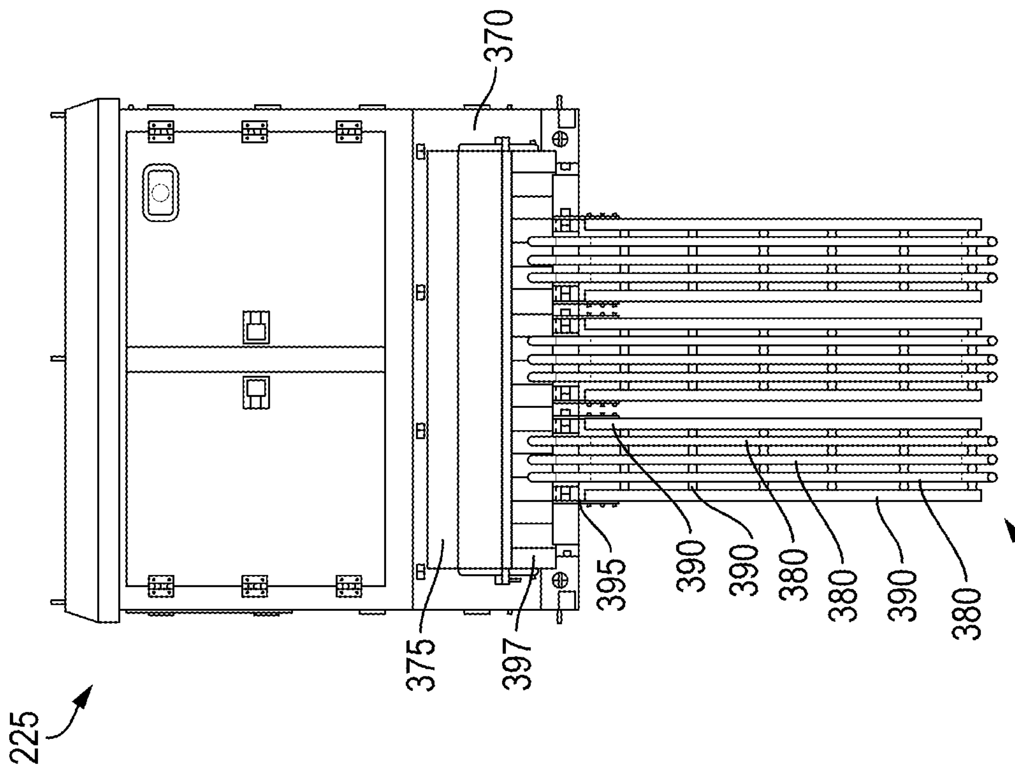


FIG. 3I

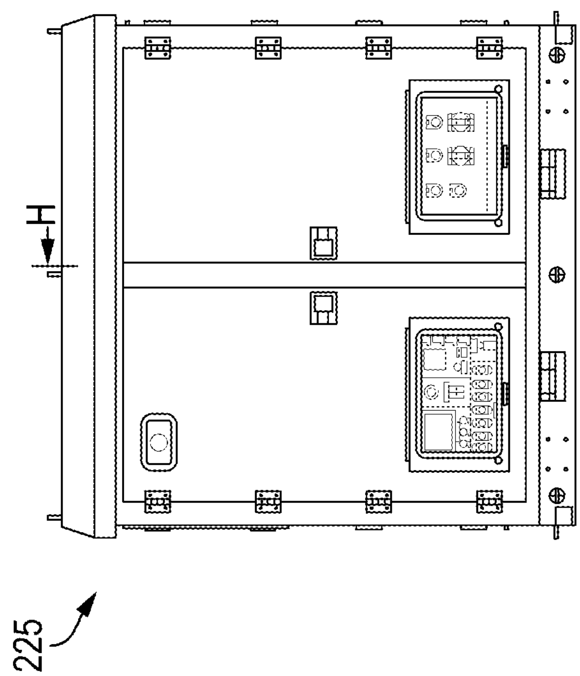


FIG. 3H

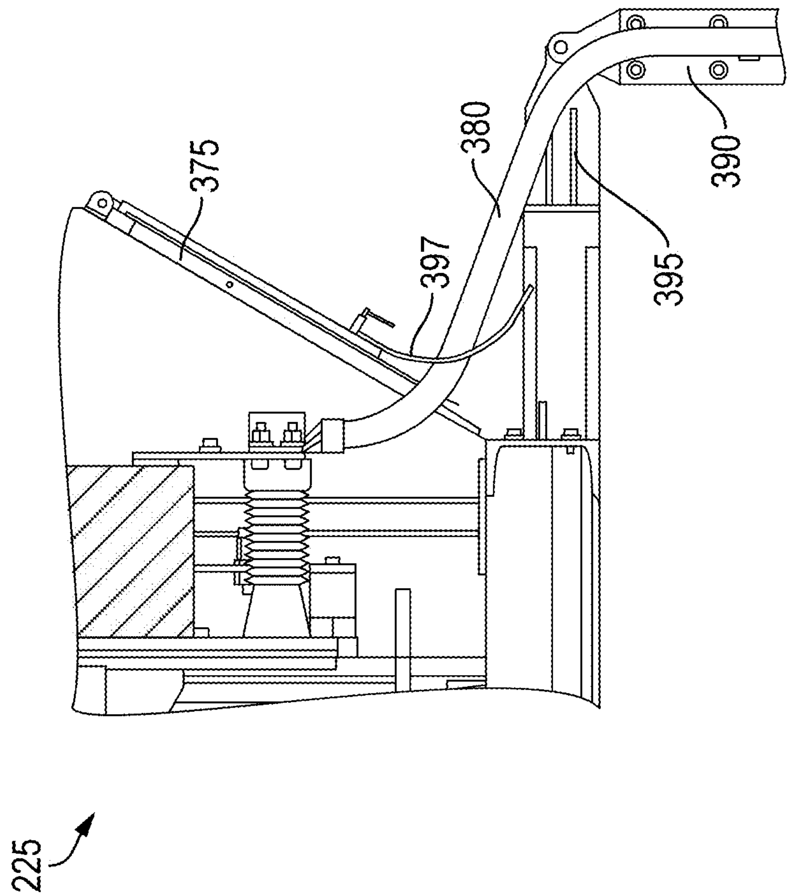


FIG. 3K

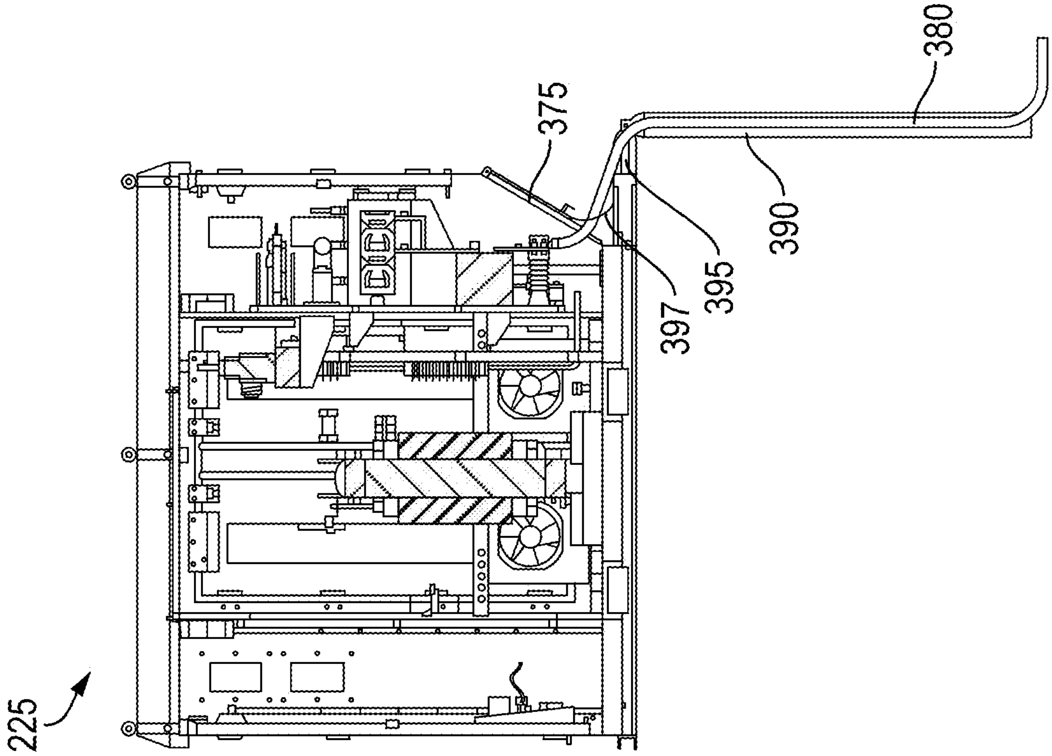


FIG. 3J

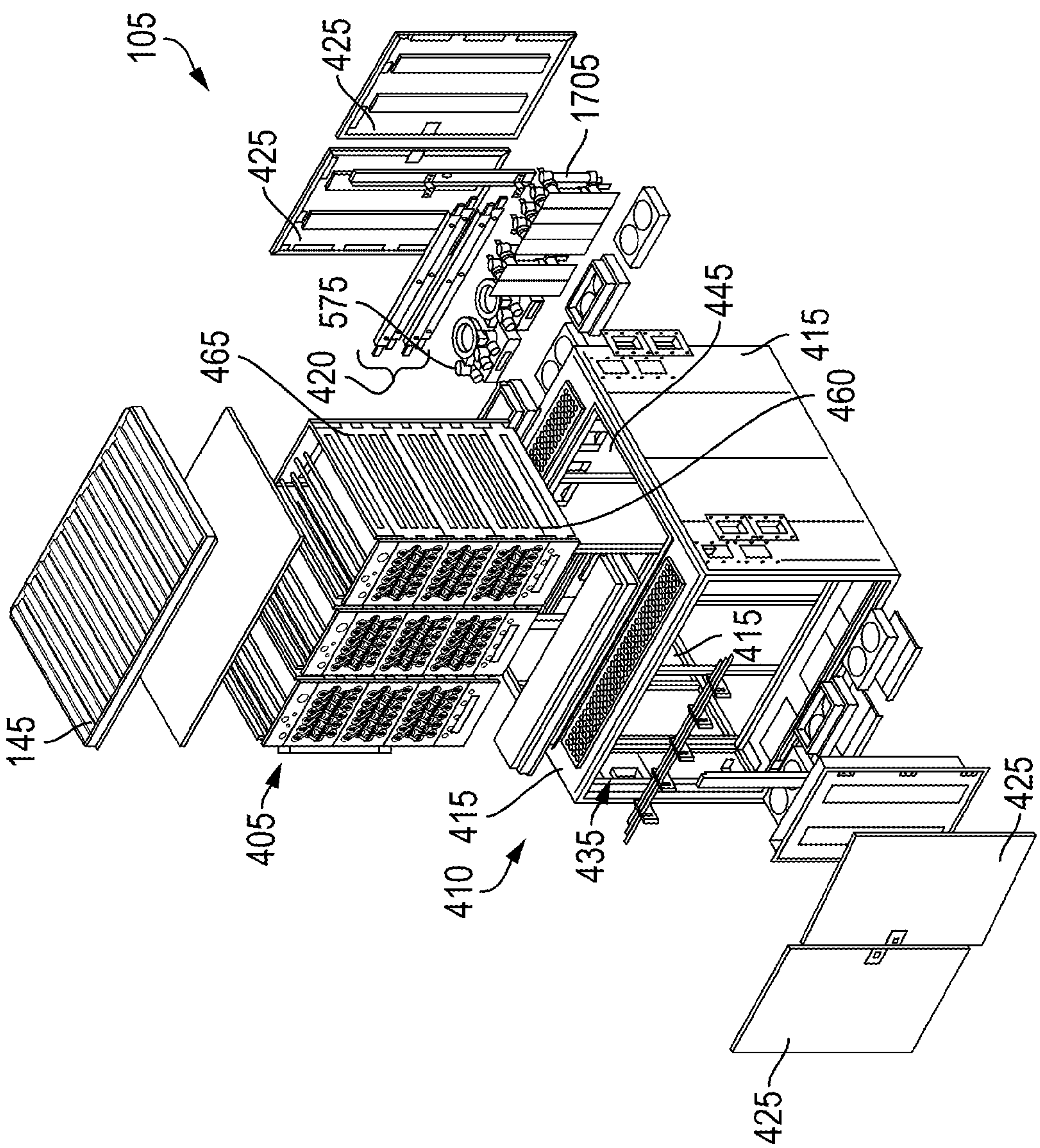

105
425
425
1705
425
575
420
465
445
415
460
145
405
410
415
435
415
425
425

FIG. 4A

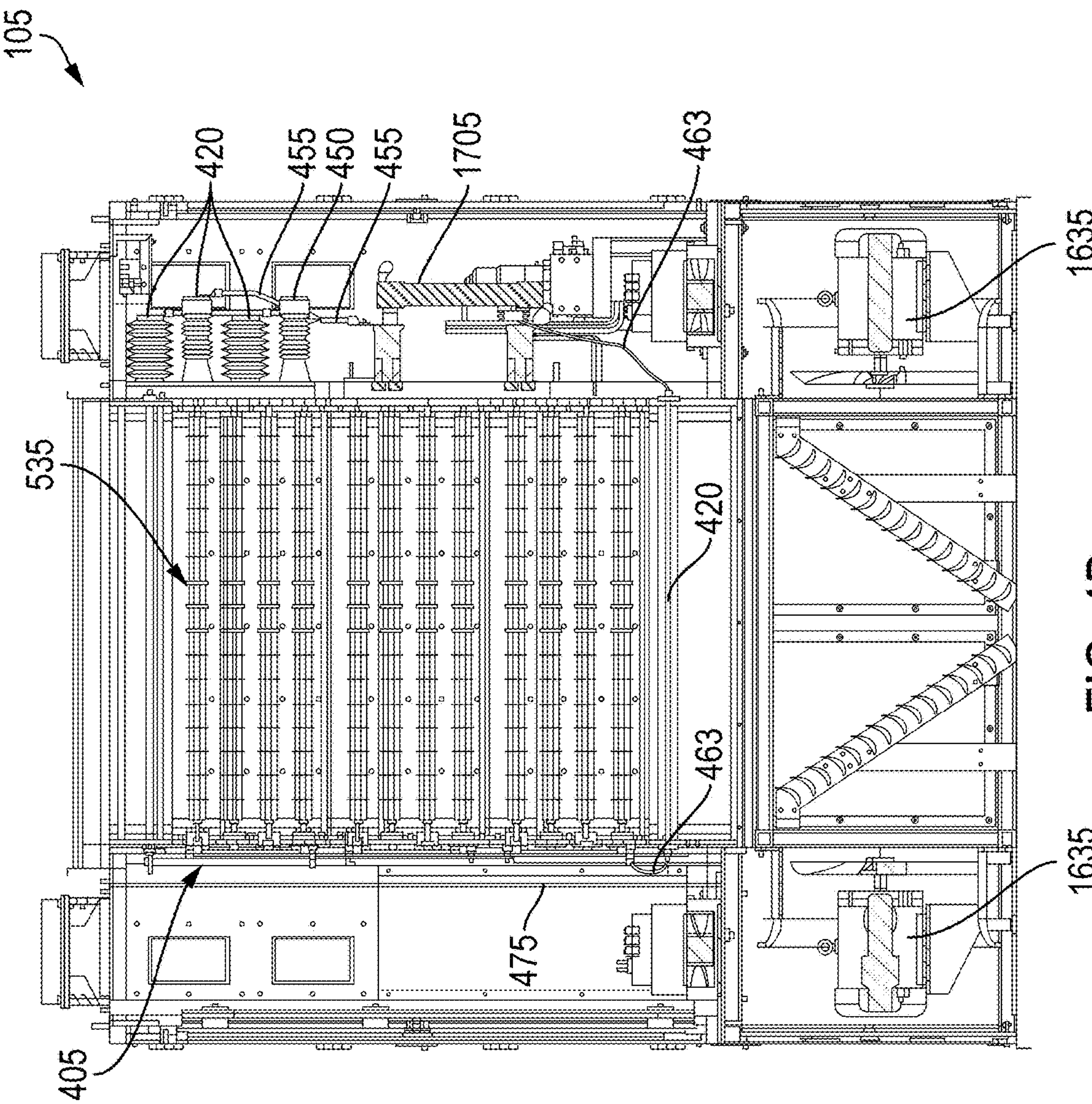


FIG. 4B

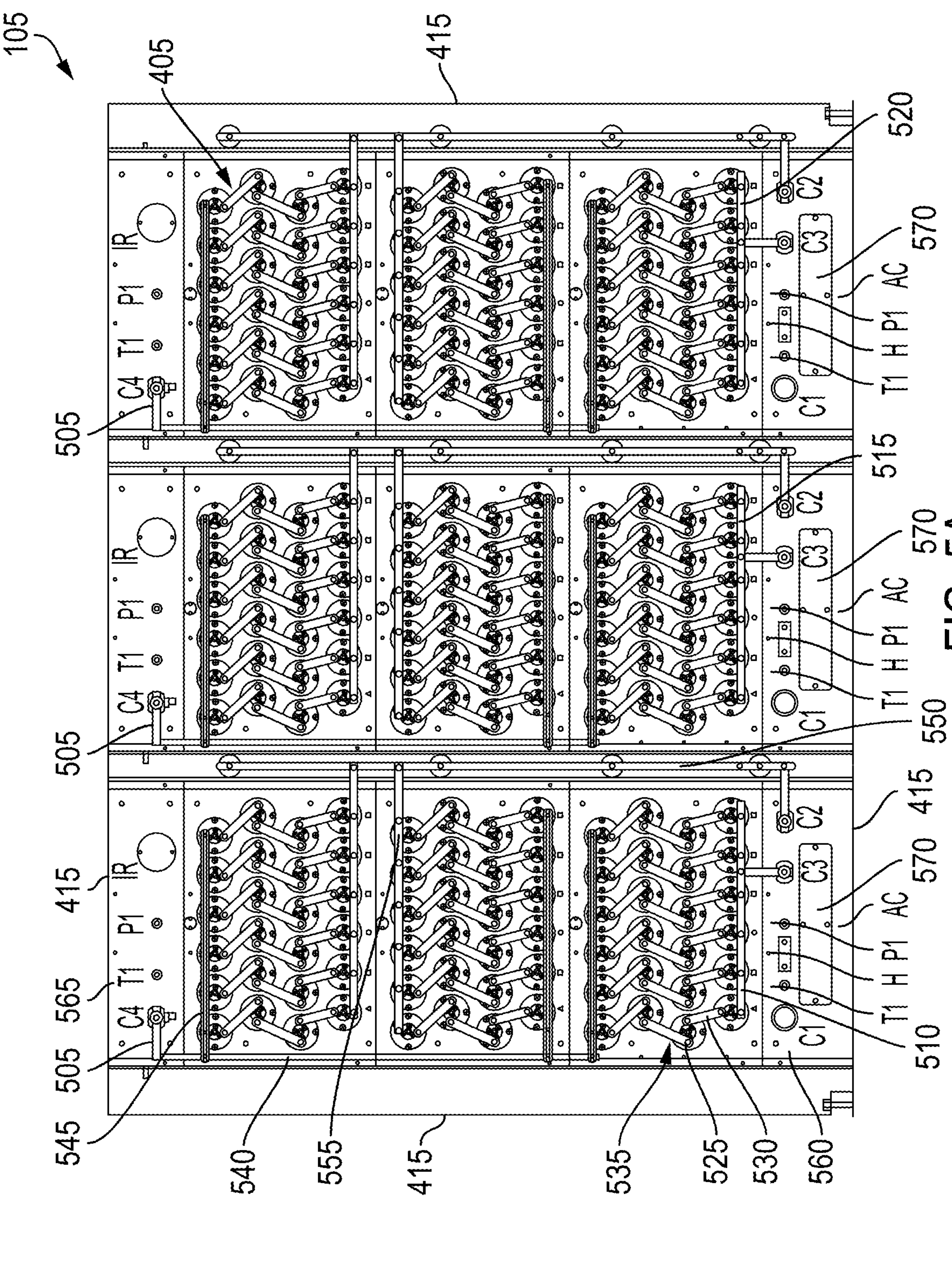

105
405
415
520
505
570
AC
P1
H
T1
C1
C2
C3
C4
IR
515
550
510
565
545
540
555
535
525
530
560

FIG. 5A

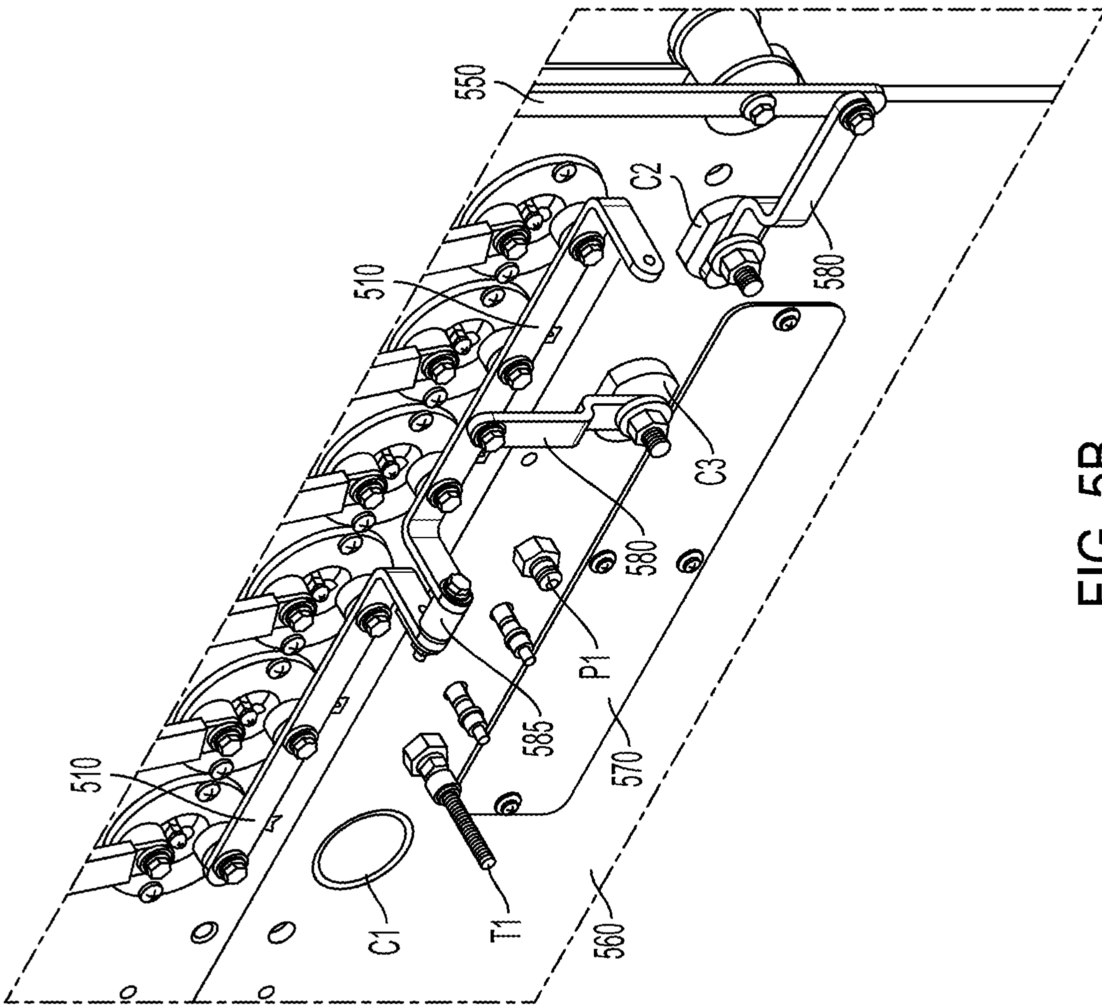


FIG. 5B

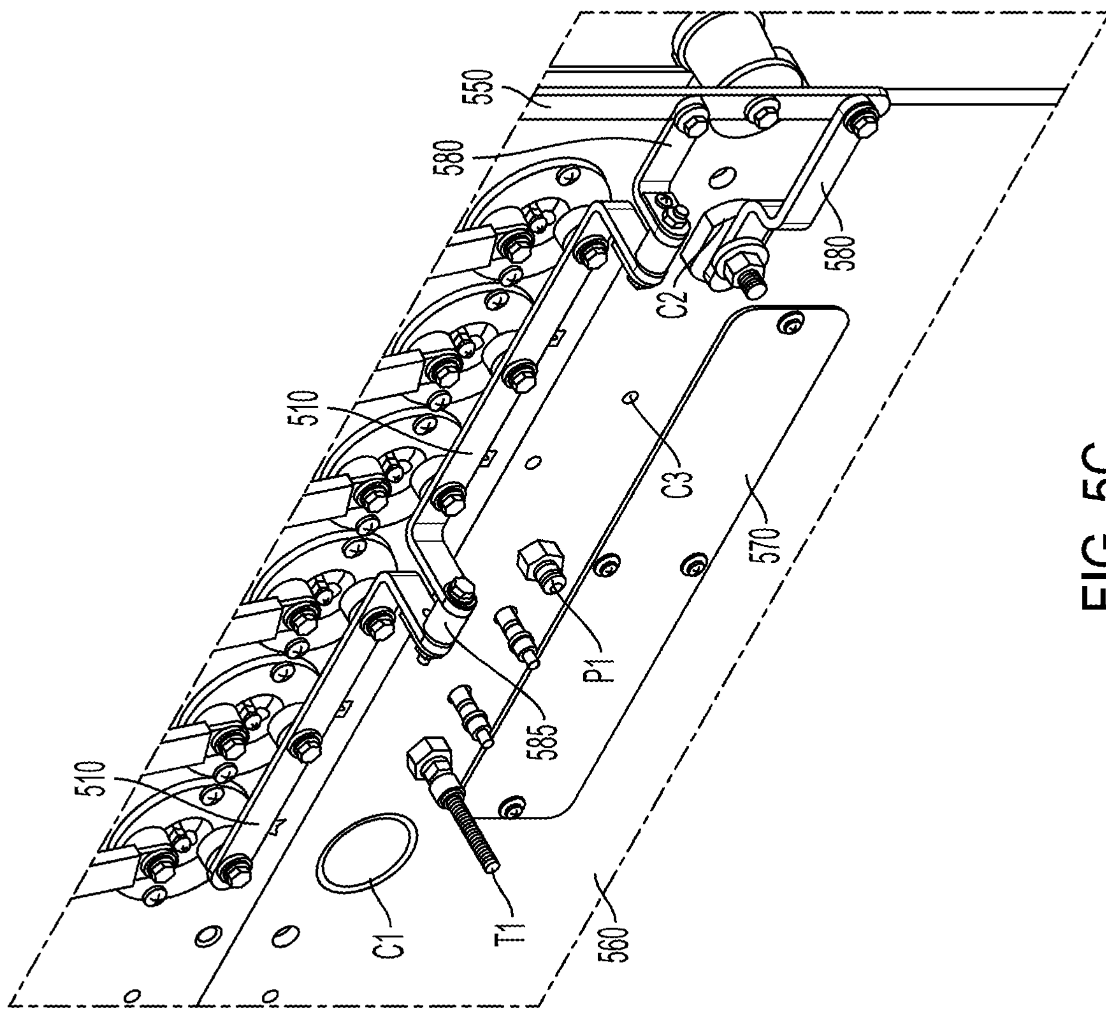


FIG. 5C

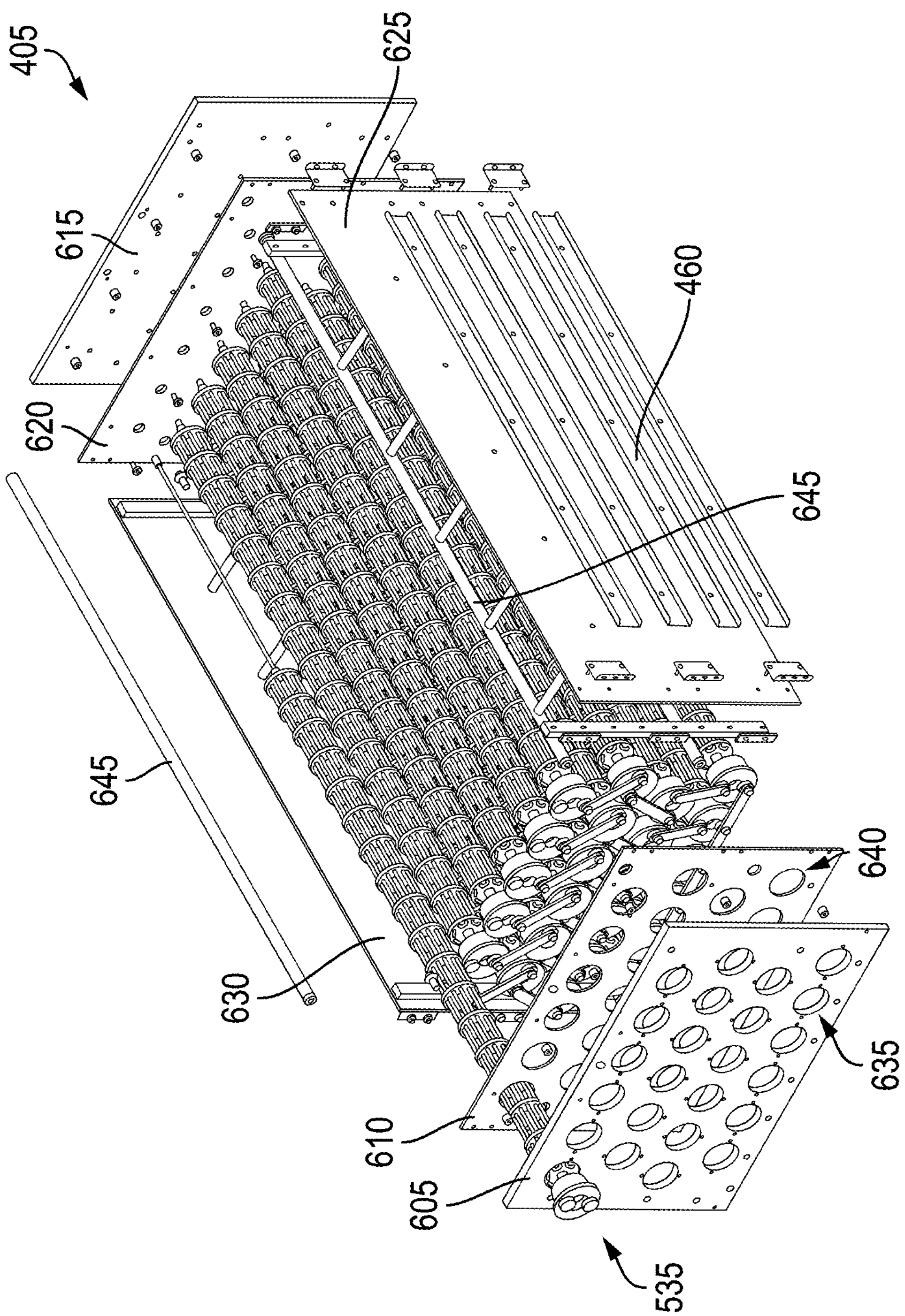


FIG. 6

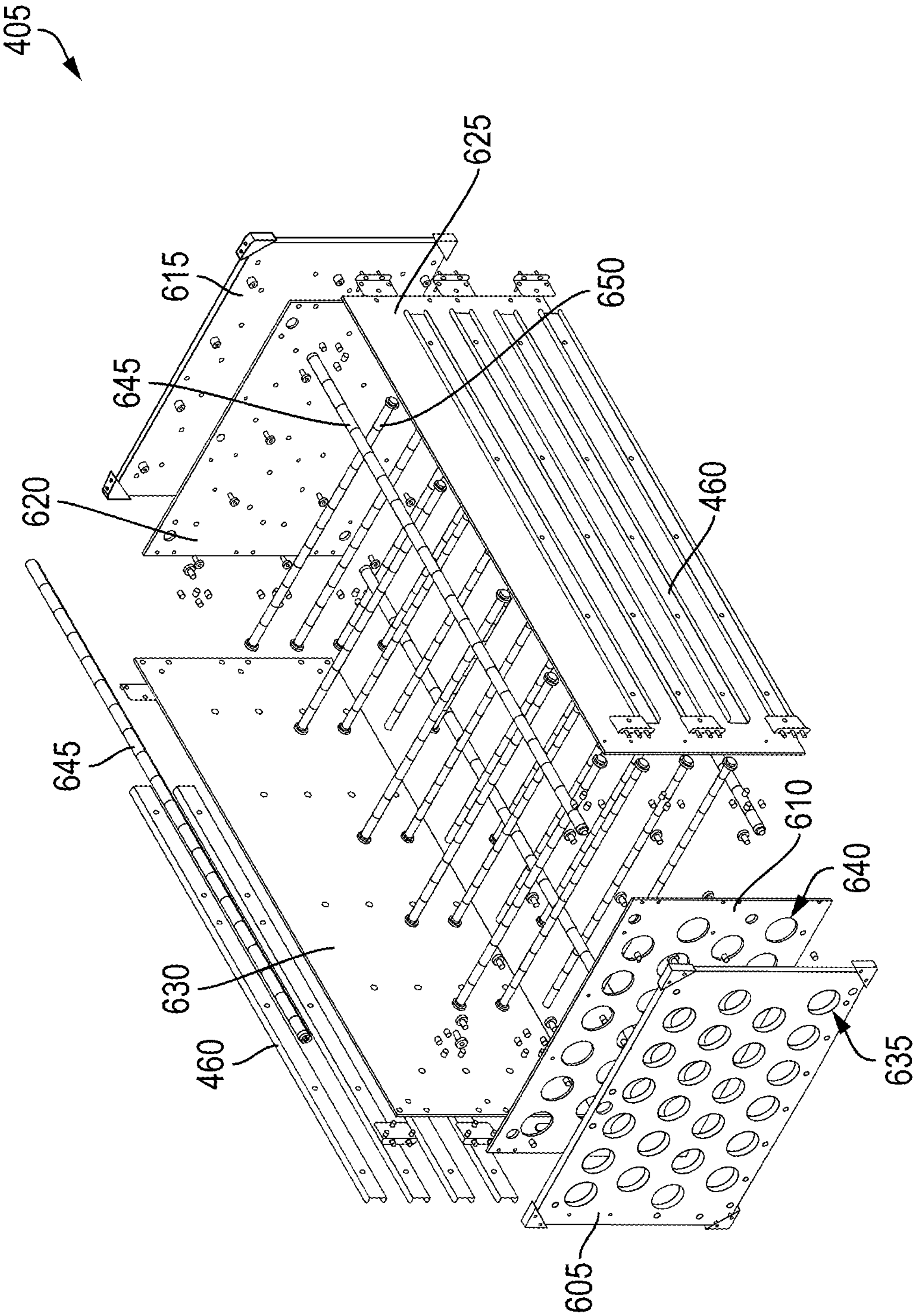


FIG. 7

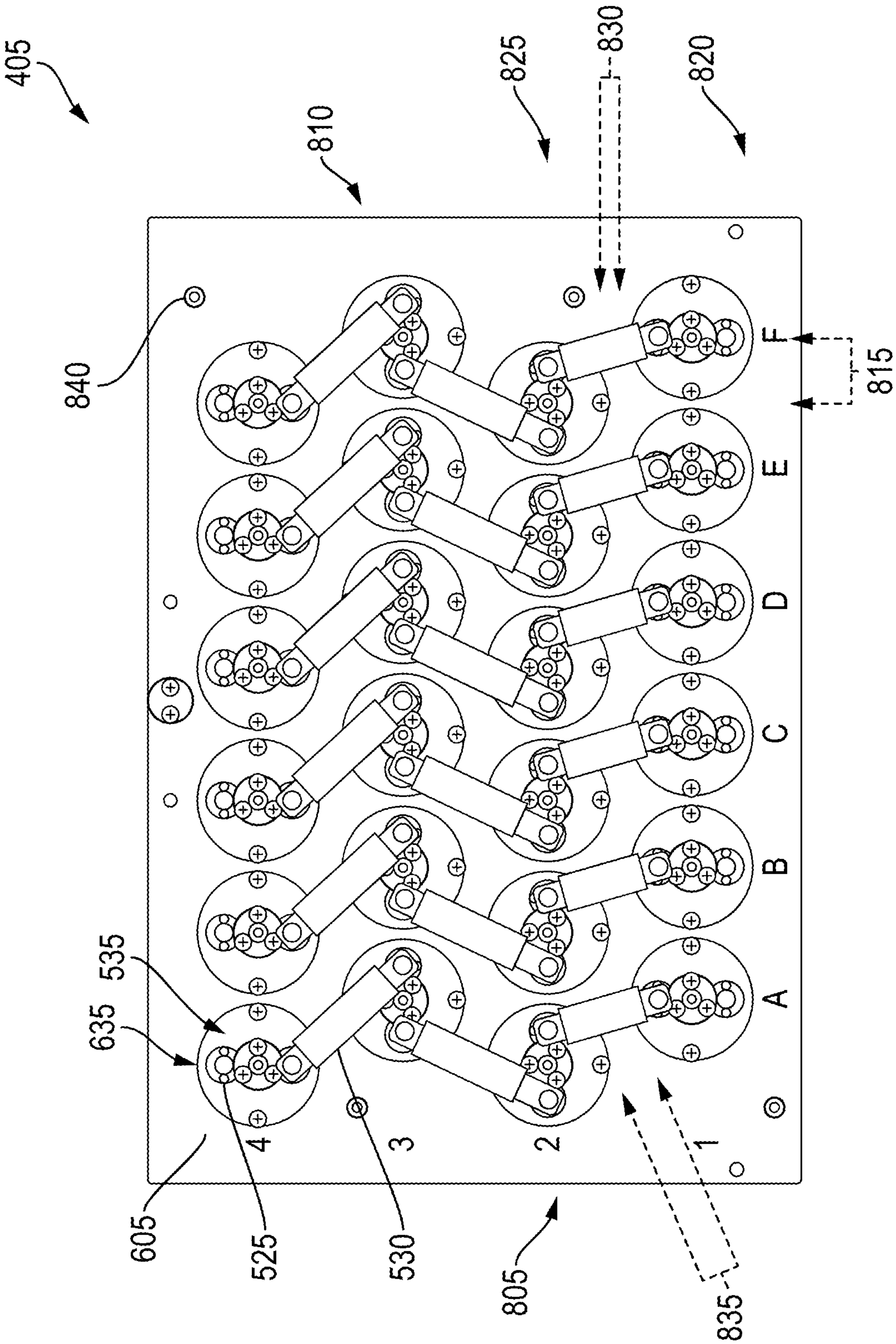

405
810
825
830
820
840
815
A
B
C
D
E
F
1
2
3
4
535
635
605
525
530
805
835

FIG. 8

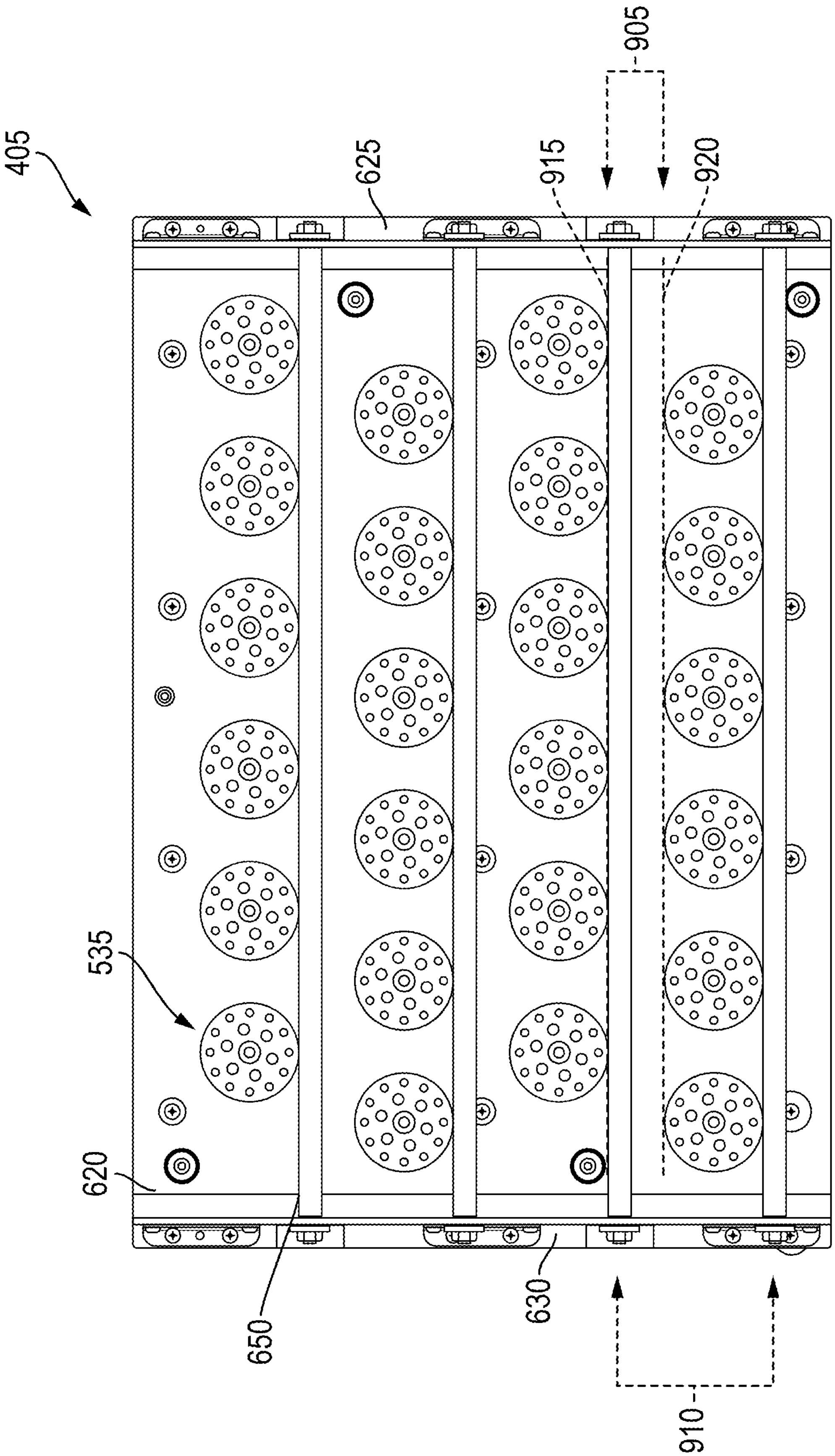


FIG. 9

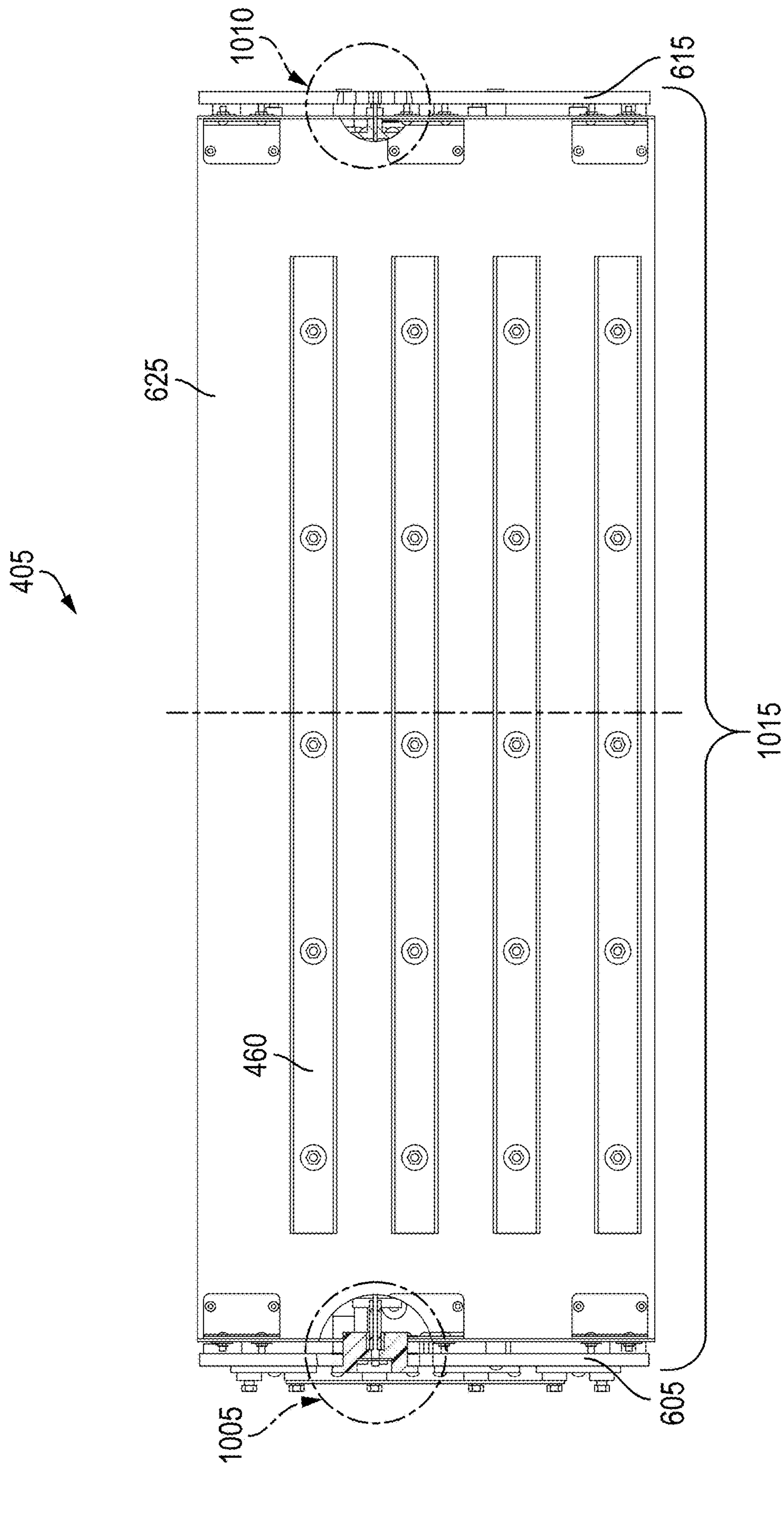


FIG. 10

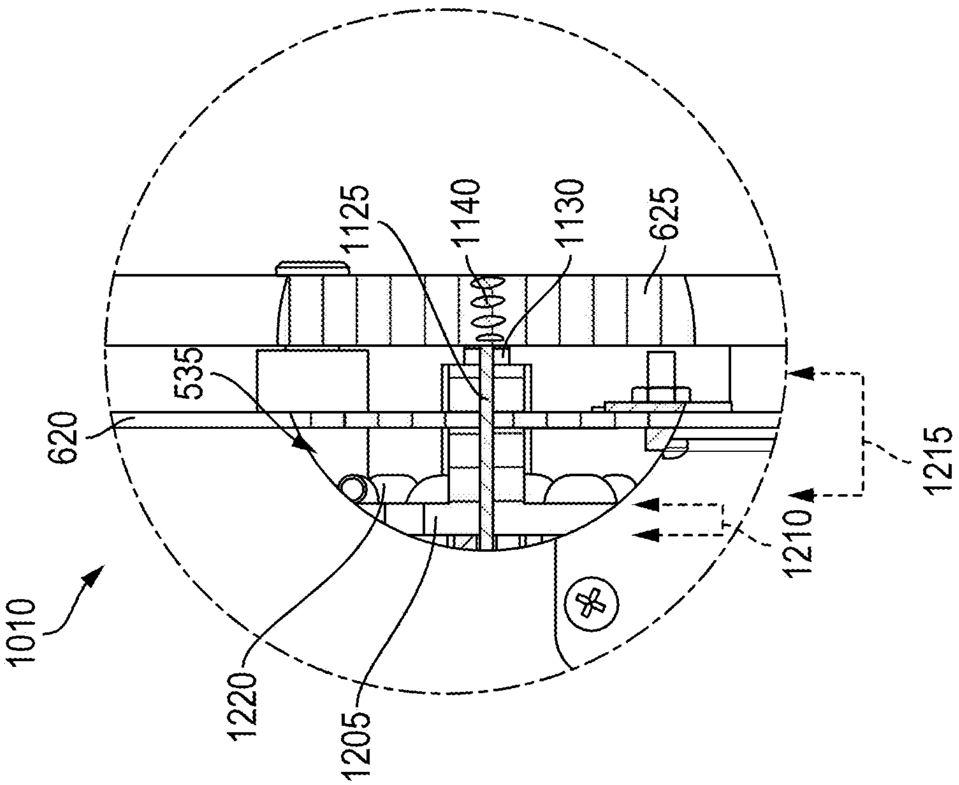

1010
620
535
1125
1140
1130
625
1215
1210
1220
1205

FIG. 12

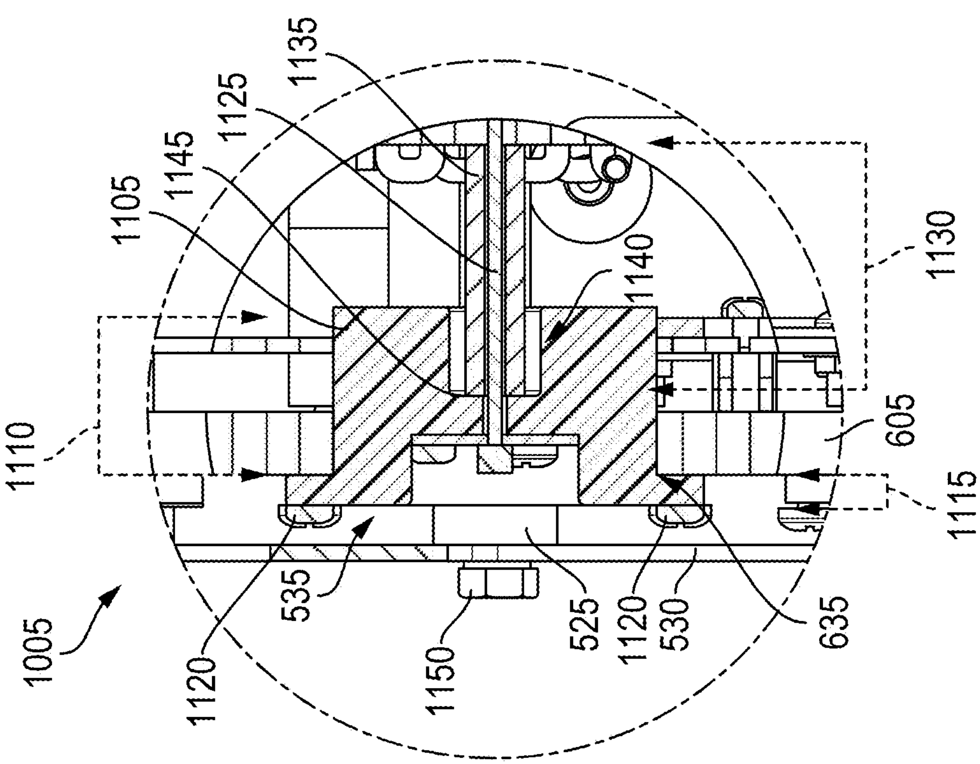

1135
1125
1145
1105
1110
1140
1130
605
1115
1005
535
1120
1150
525
1120
530
635

FIG. 11

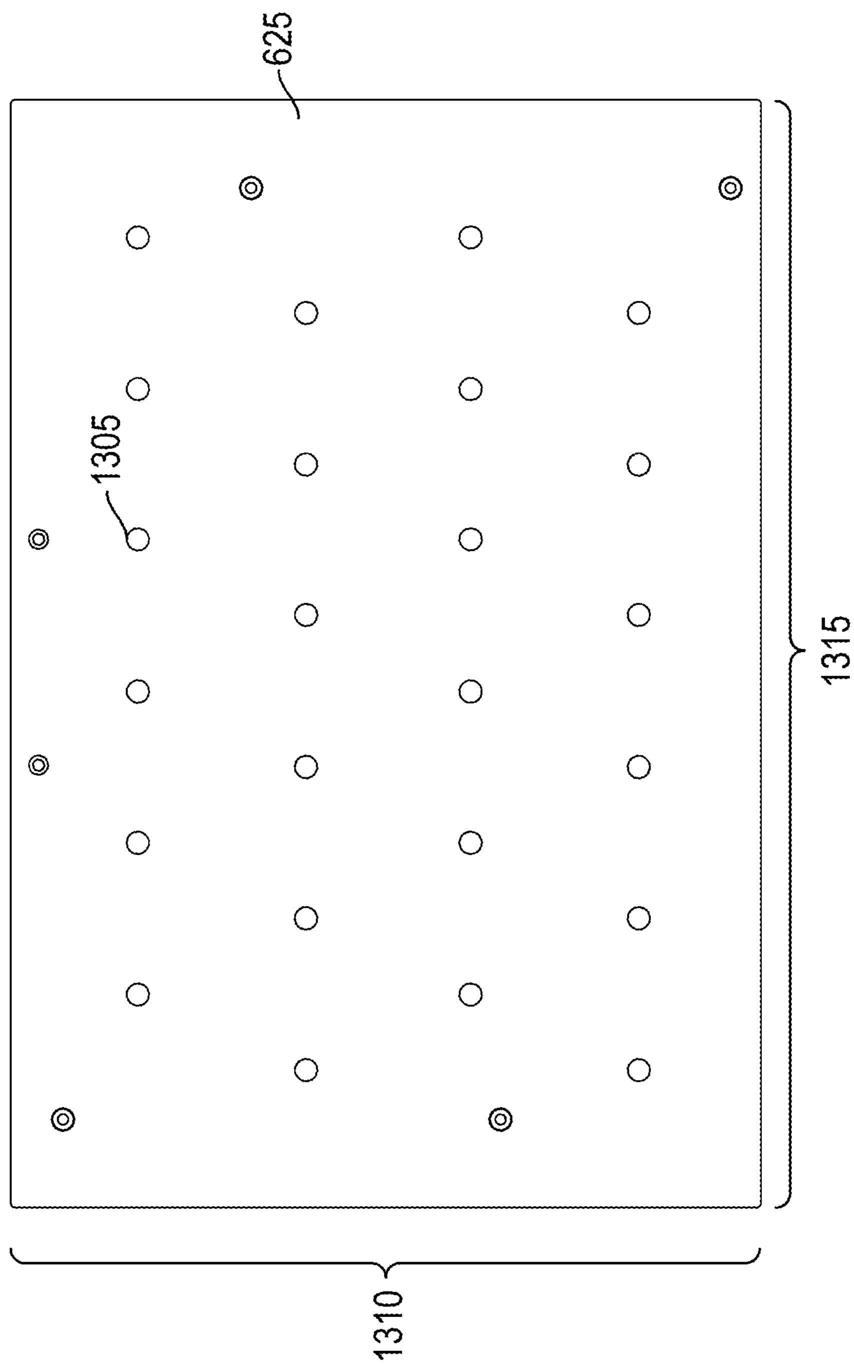


FIG. 13

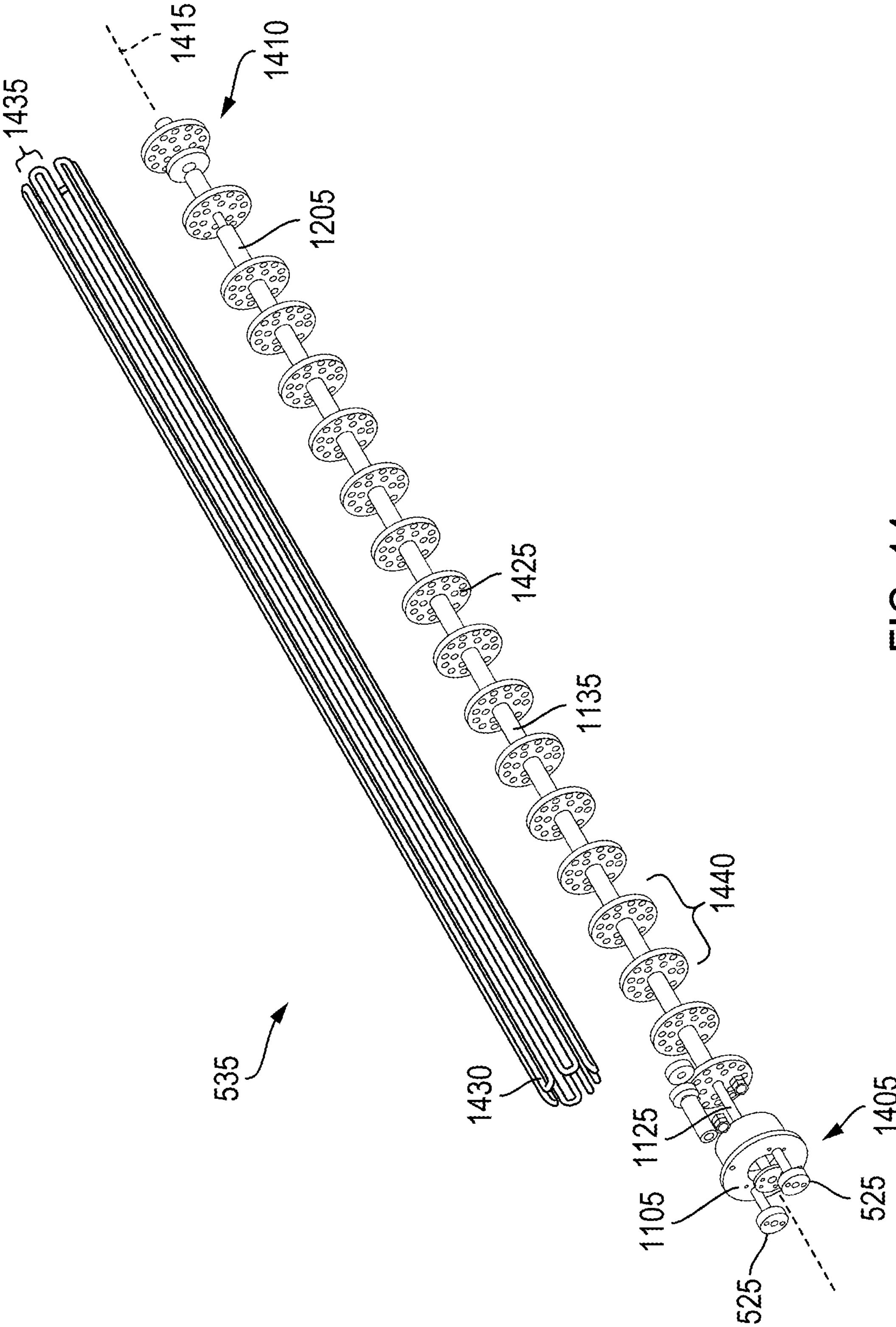

1415
1410
1435
1205
1425
1135
1440
535
1430
1125
1405
1105
525
525

FIG. 14

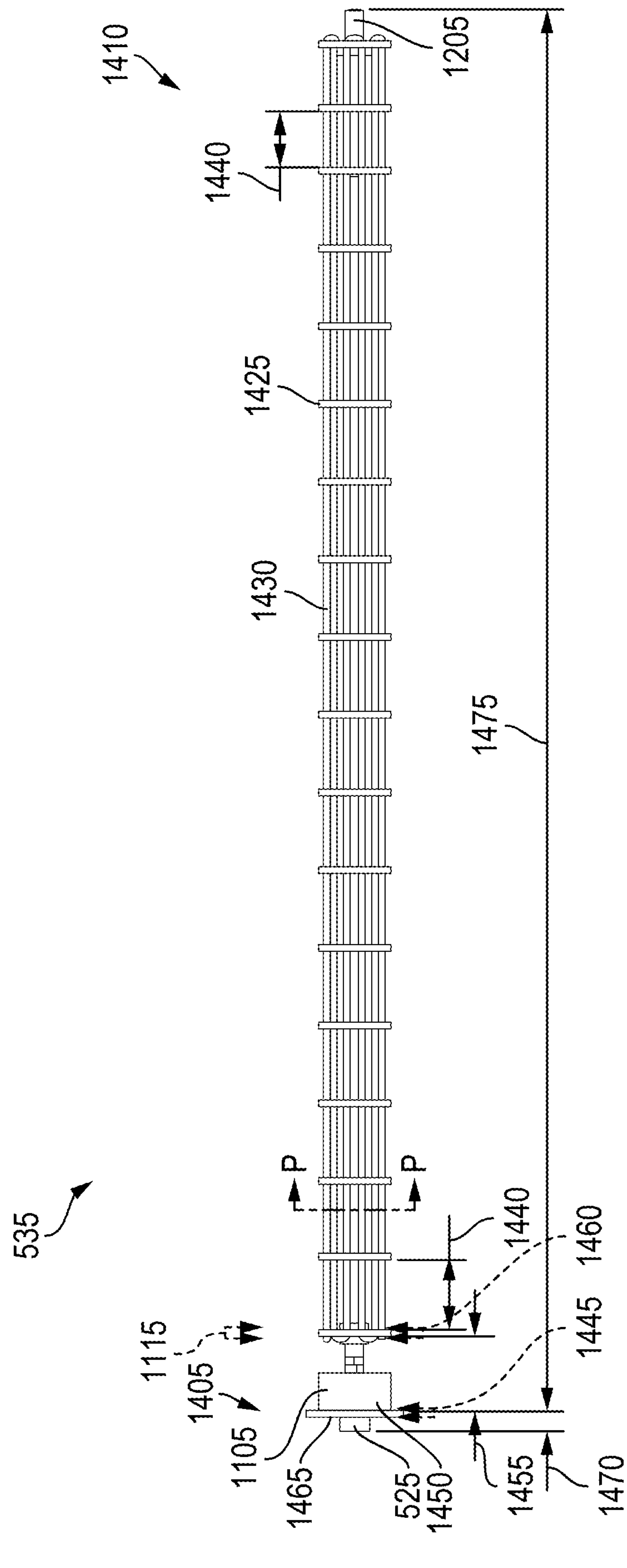

1410
1205
1440
1425
1430
1475
P
P
535
1440
1460
1445
1115
1405
1105
1465
525
1450
1455
1470

FIG. 15A

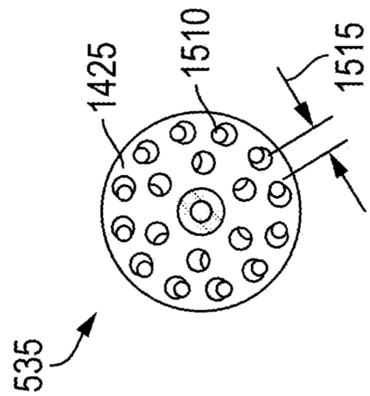


FIG. 15C

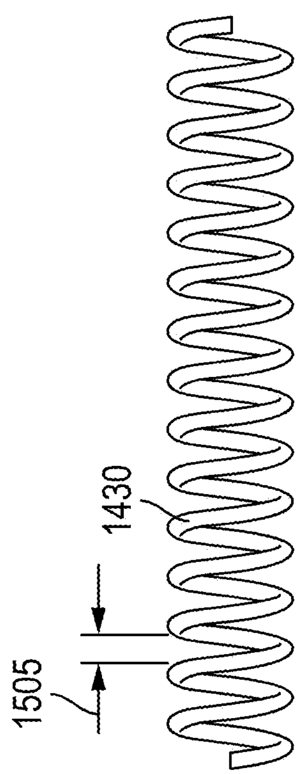


FIG. 15B

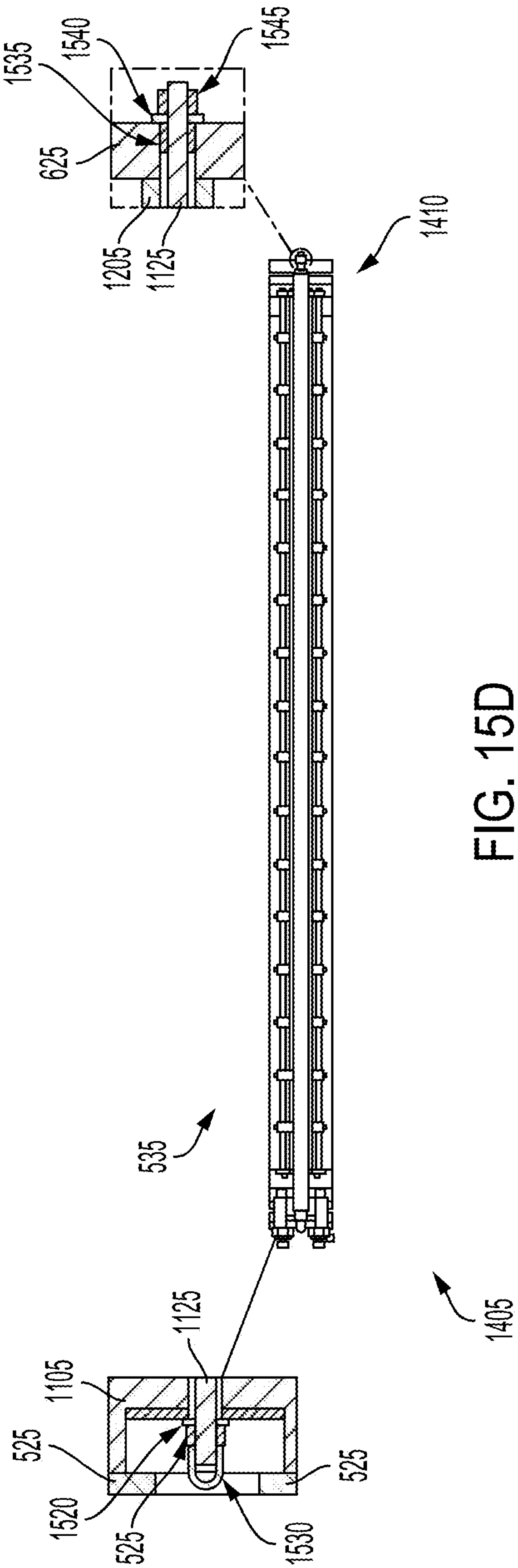

1535
1540
1545
625
1205
1125
1410
535
1405
1125
1105
525
525
1520
1525
1530

FIG. 15D

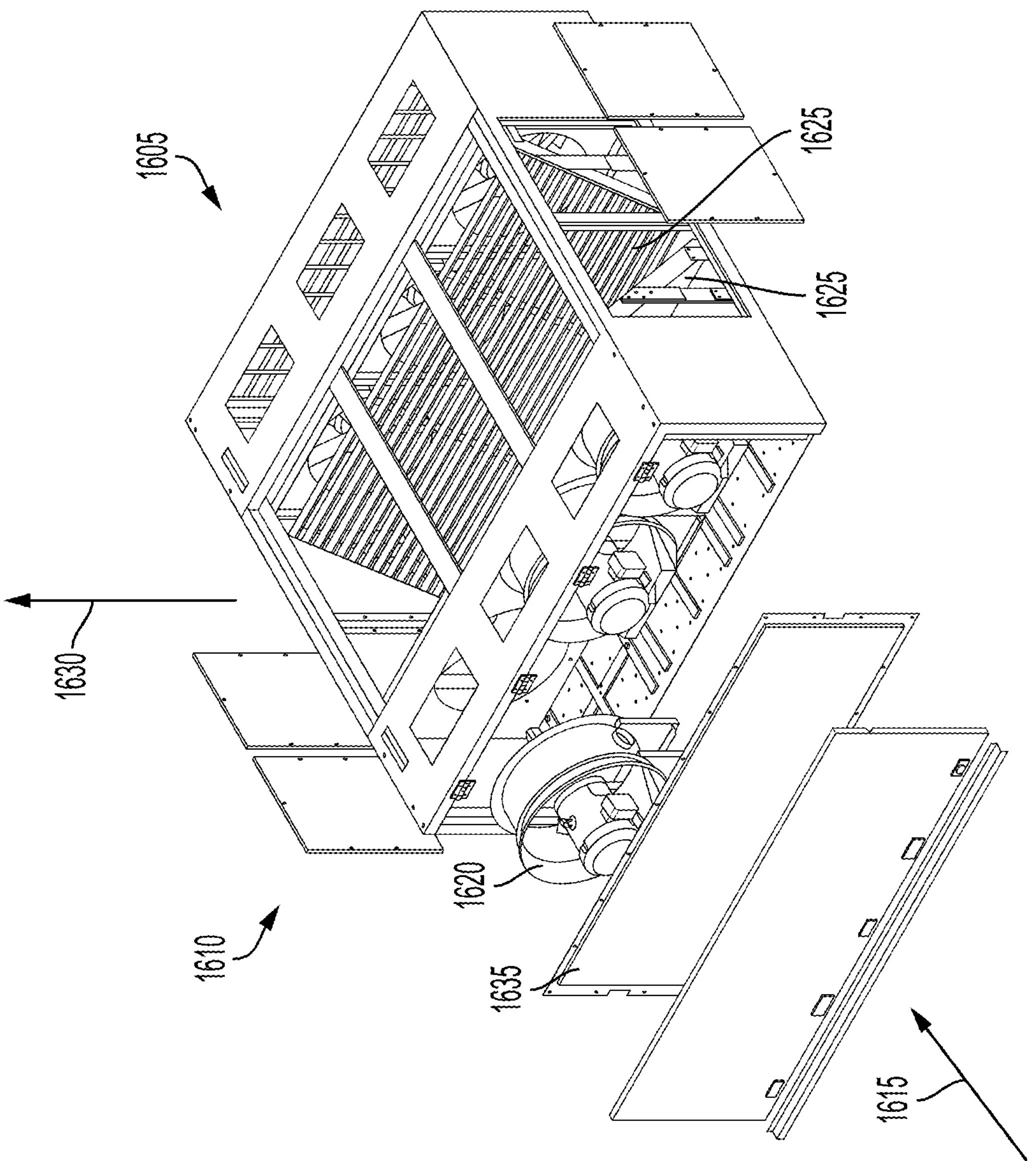


FIG. 16A

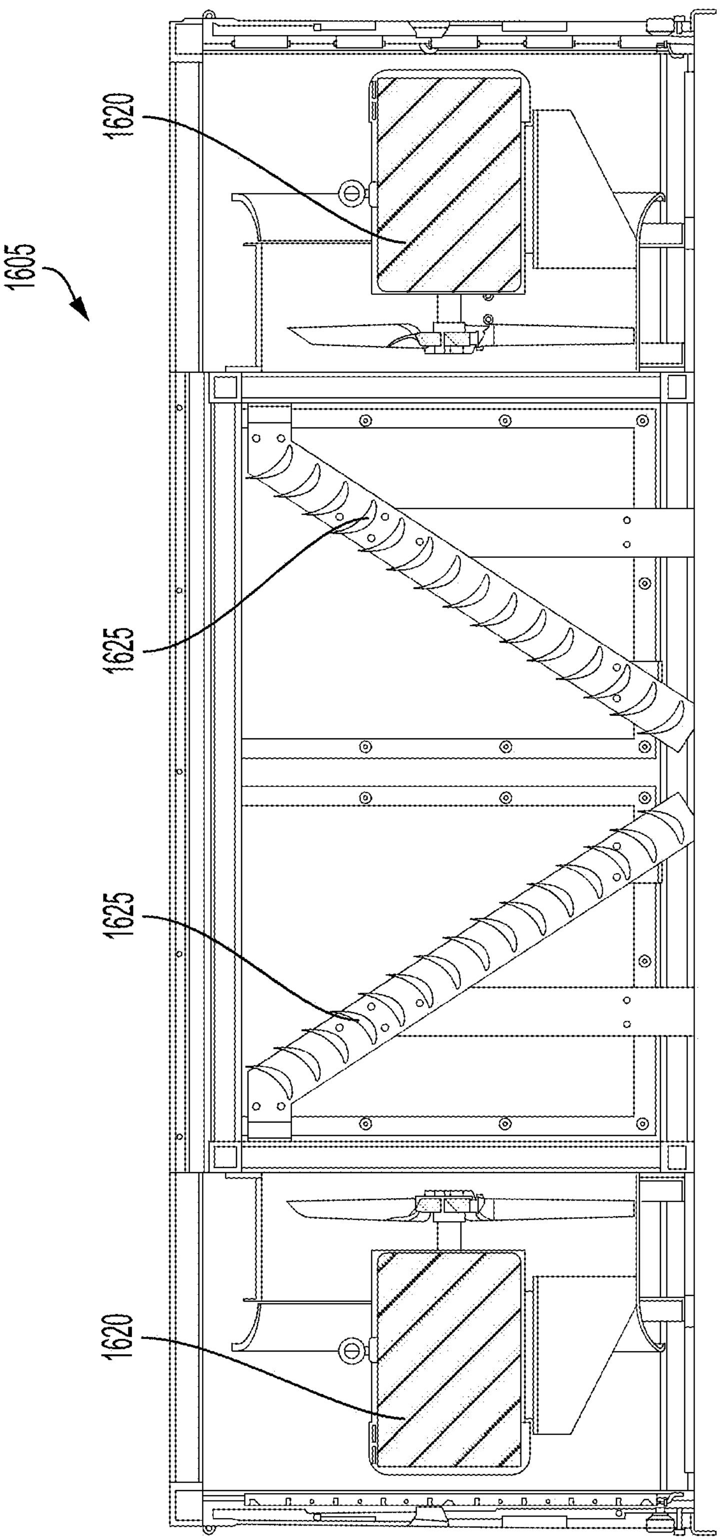


FIG. 16B

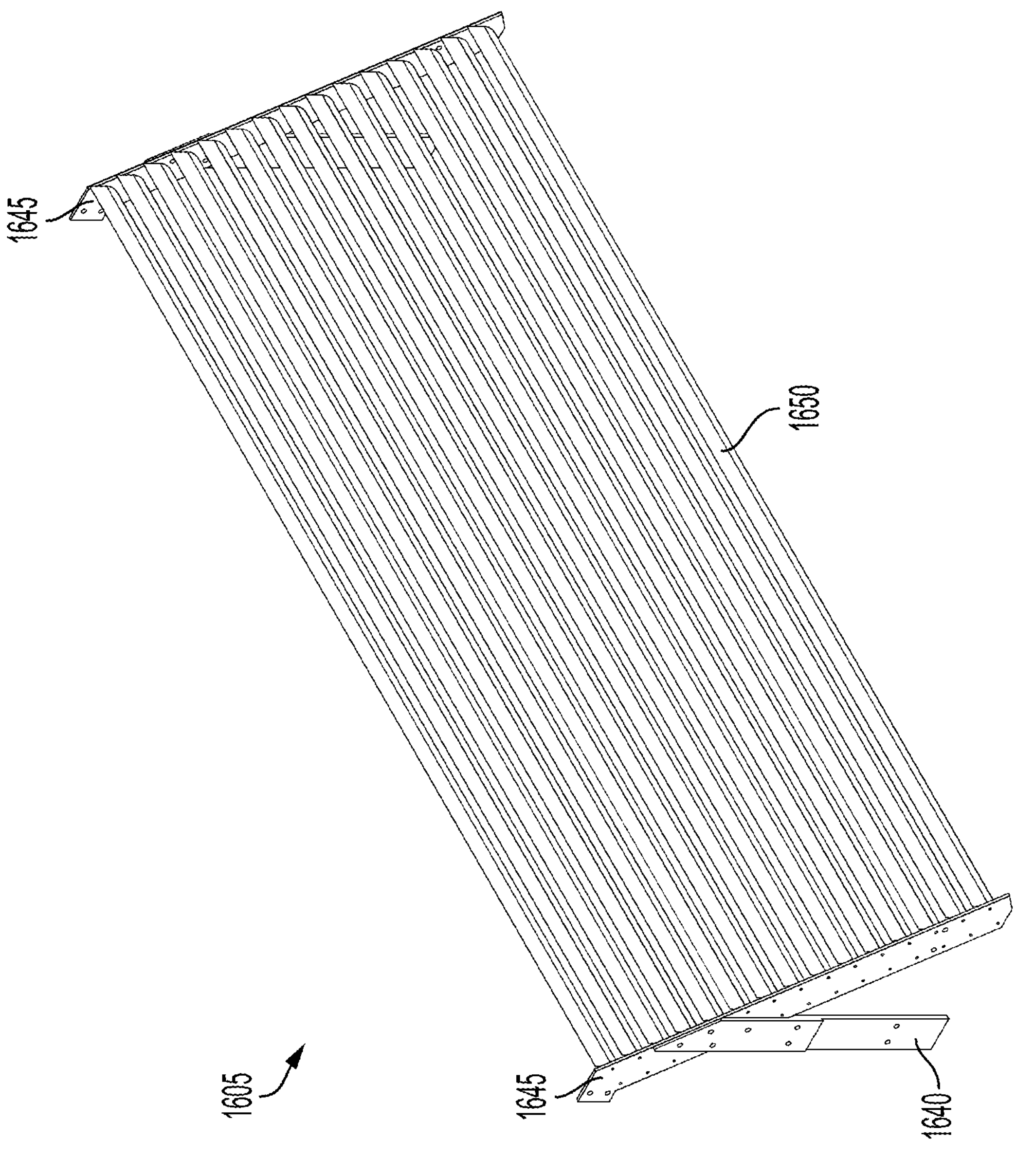


FIG. 16C

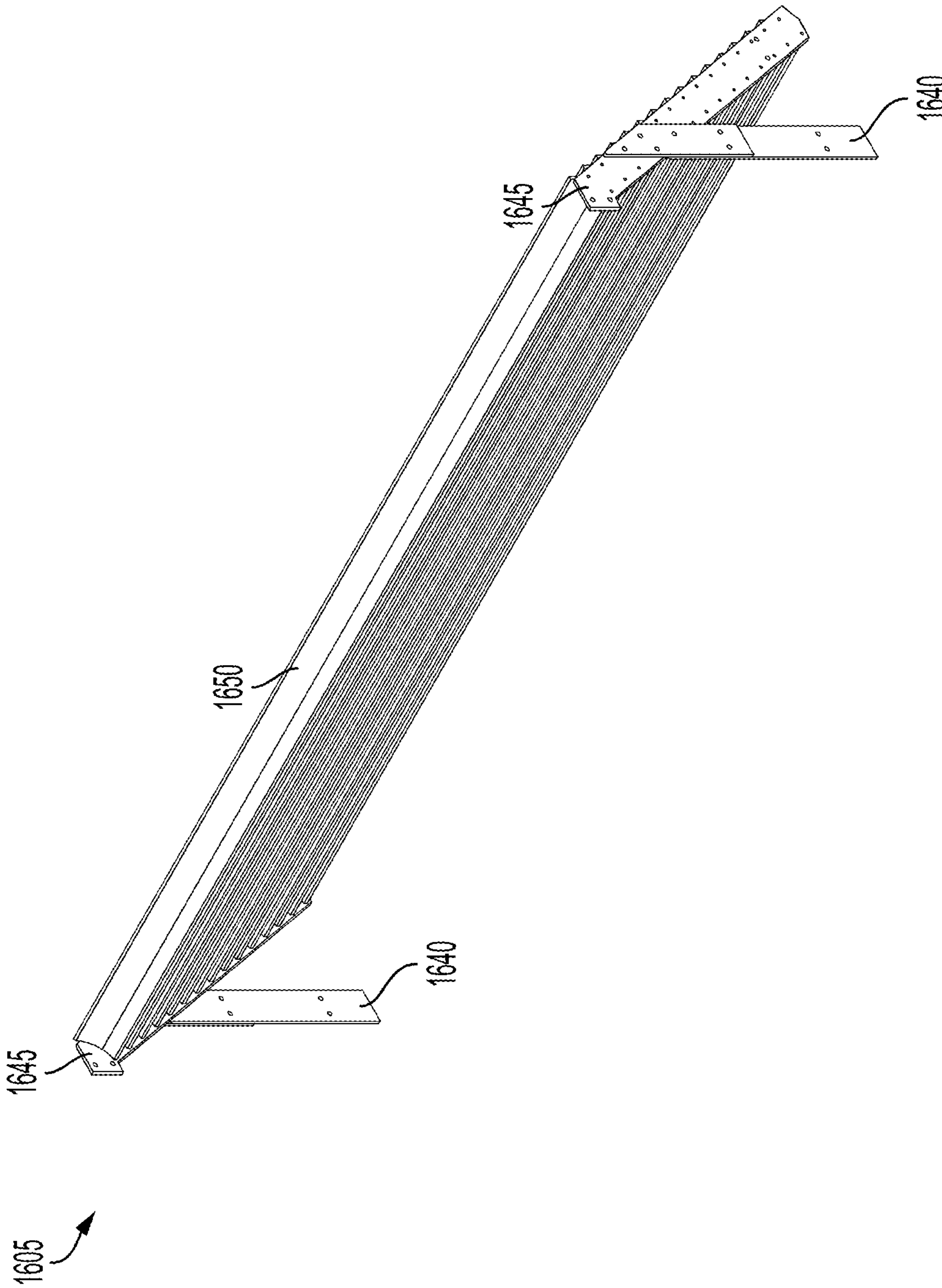


FIG. 16D

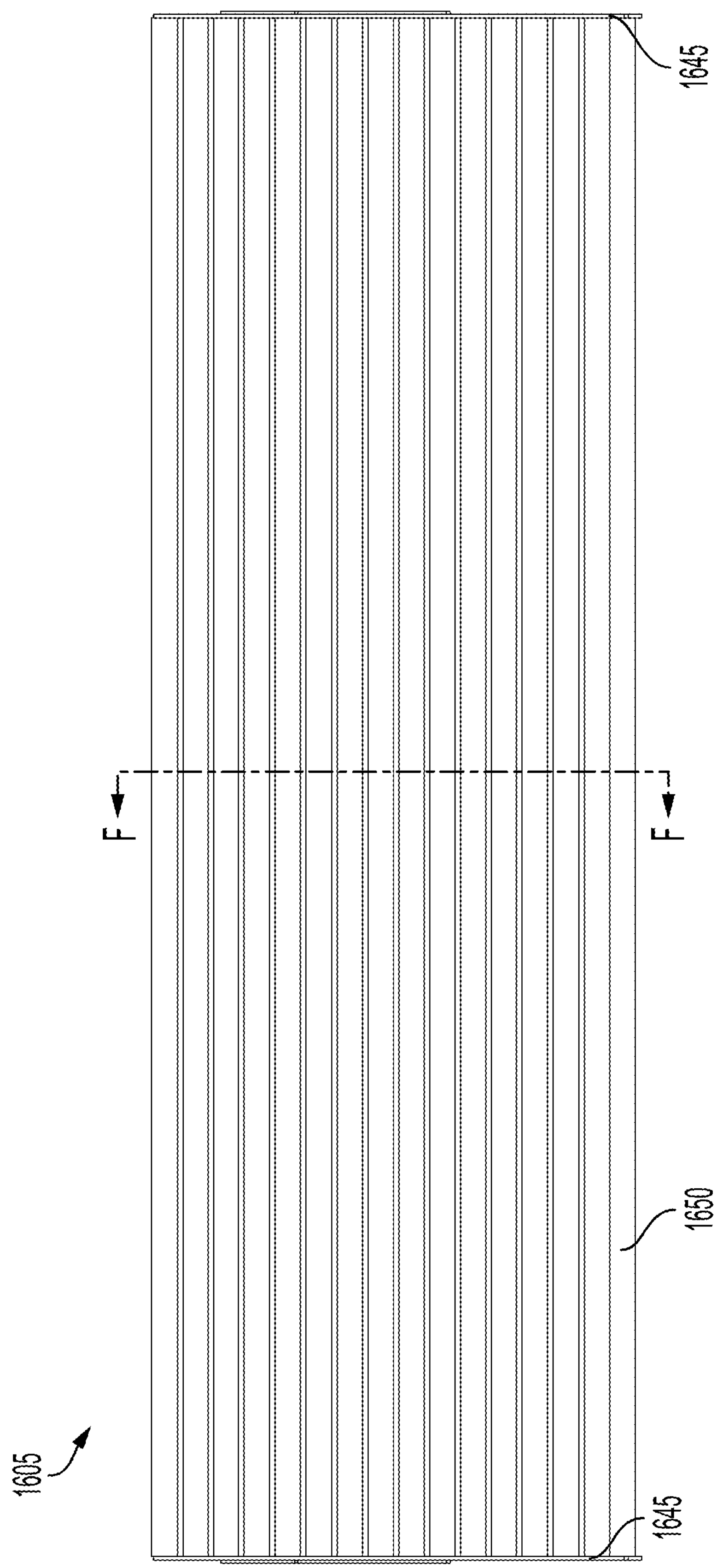


FIG. 16E

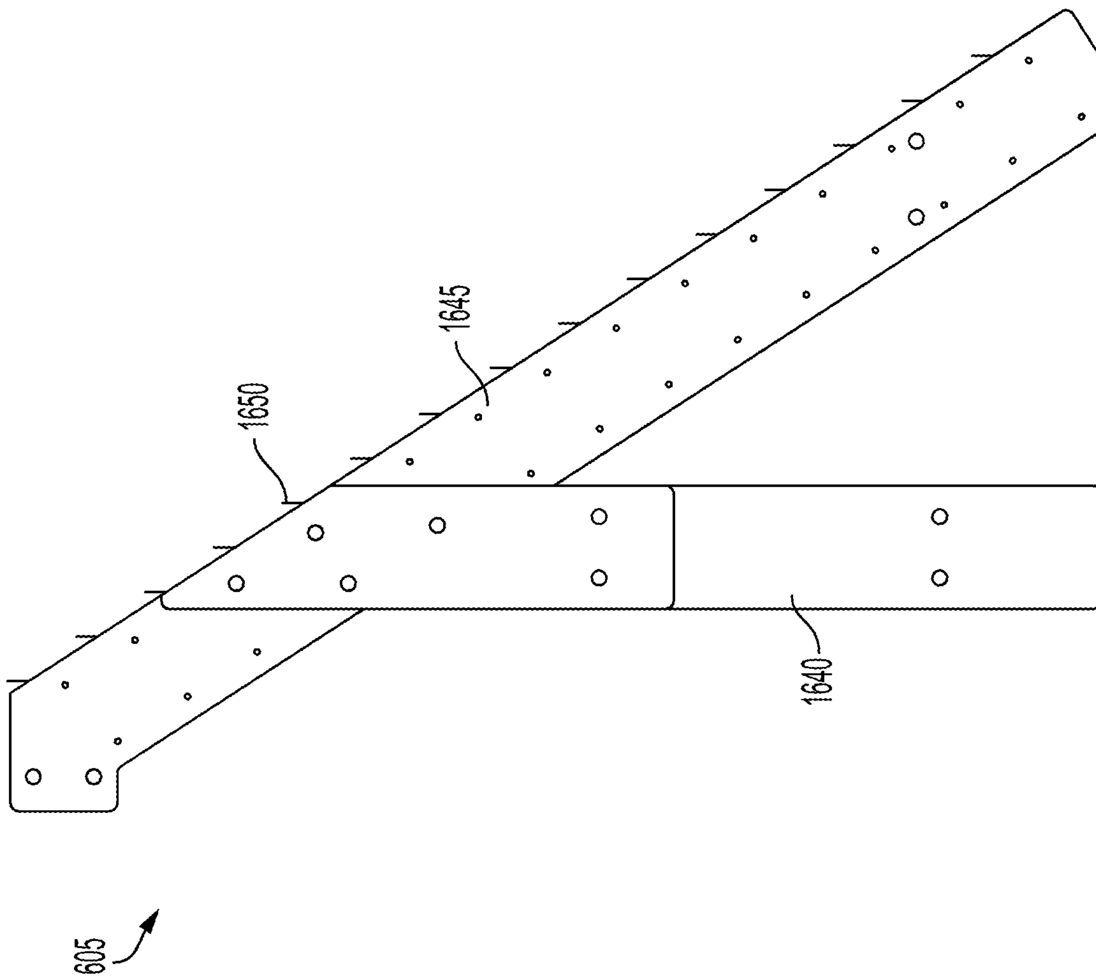


FIG. 16F

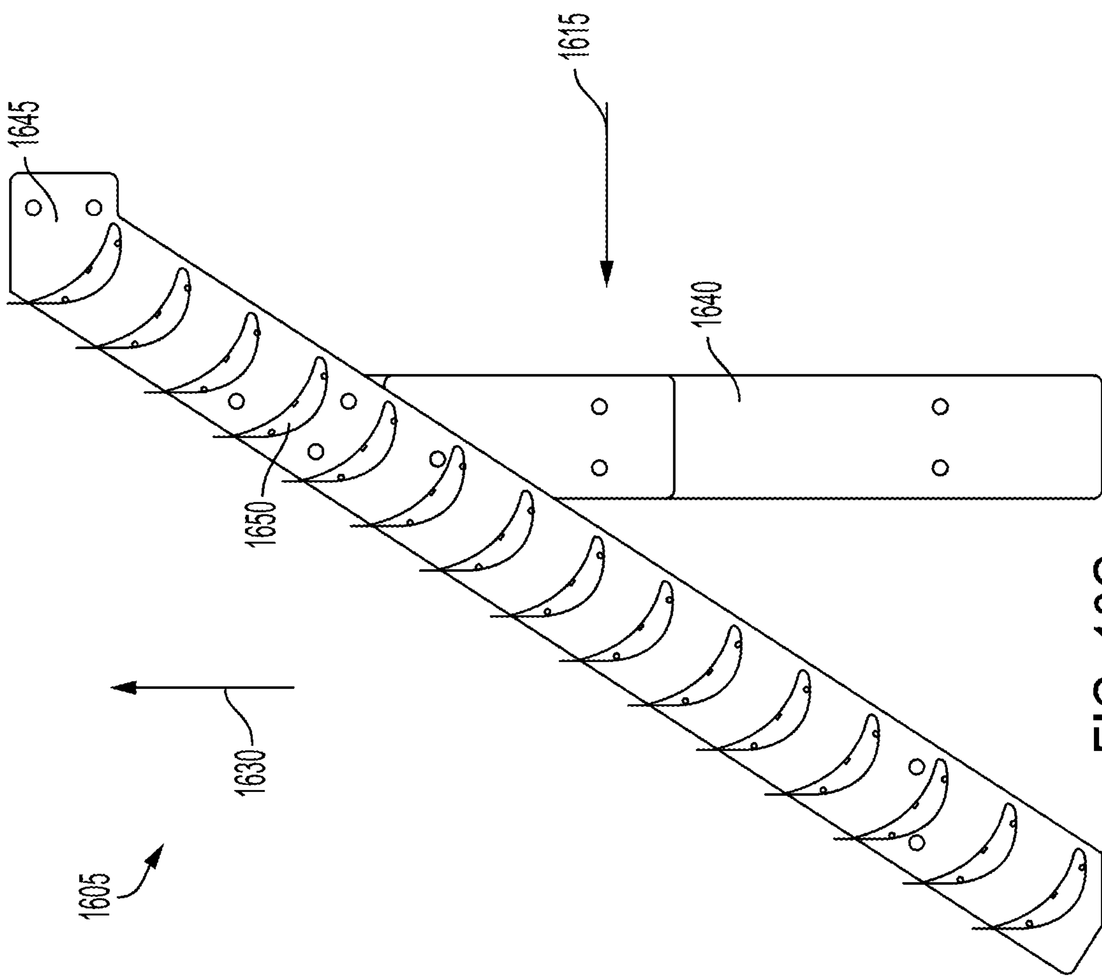


FIG. 16G

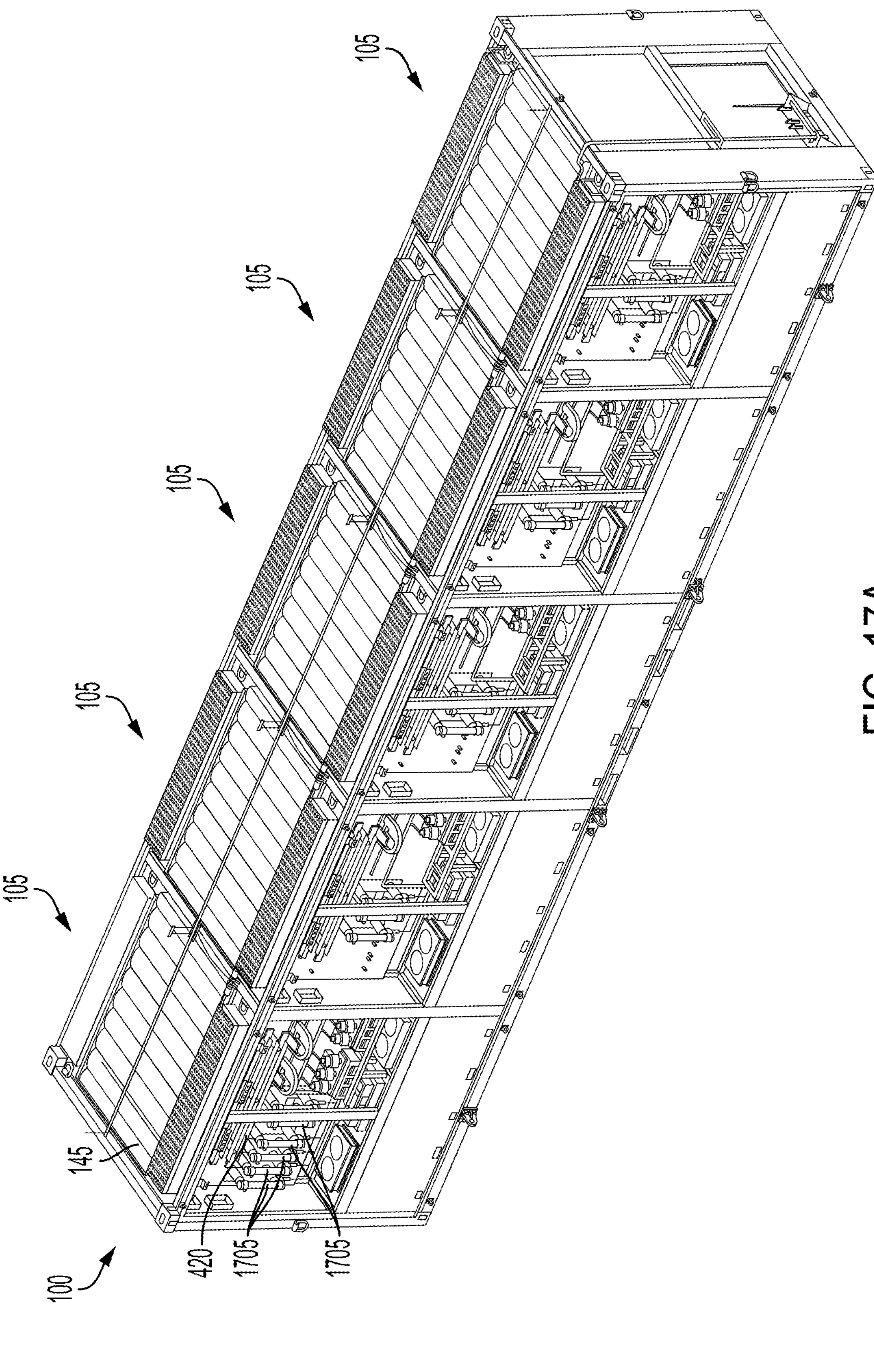


FIG. 17A

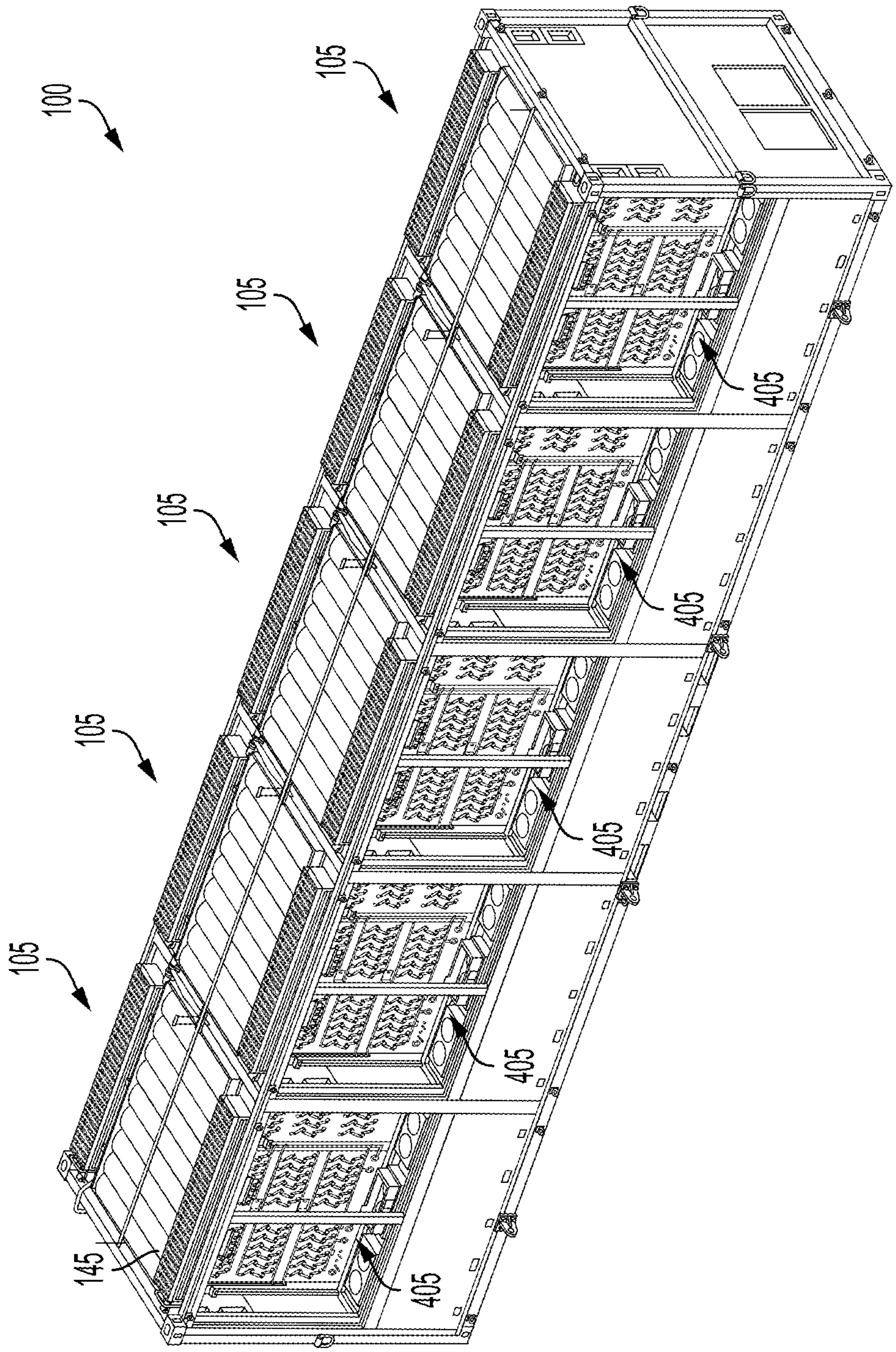


FIG. 17B

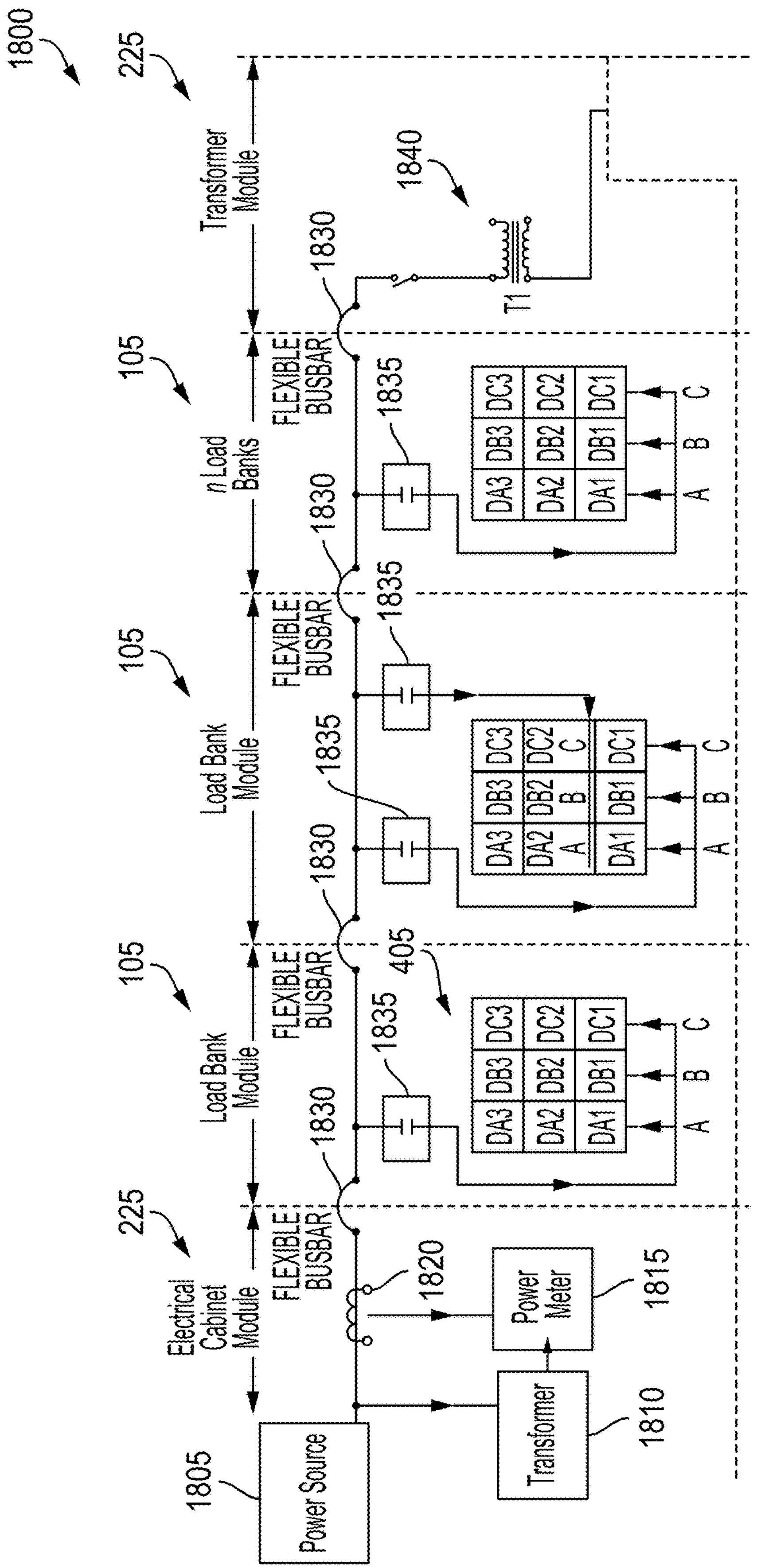

1800
225
Transformer Module
1840
1830
T1
105
n Load Banks
FLEXIBLE BUSBAR
1835
DA3
DB3
DC3
DA2
DB2
DC2
DA1
DB1
DC1
A
B
C
105
Load Bank Module
FLEXIBLE BUSBAR
1835
1830
105
Load Bank Module
FLEXIBLE BUSBAR
405
225
Electrical Cabinet Module
FLEXIBLE BUSBAR
1820
Power Meter
1815
Transformer
1810
Power Source
1805

FIG. 18

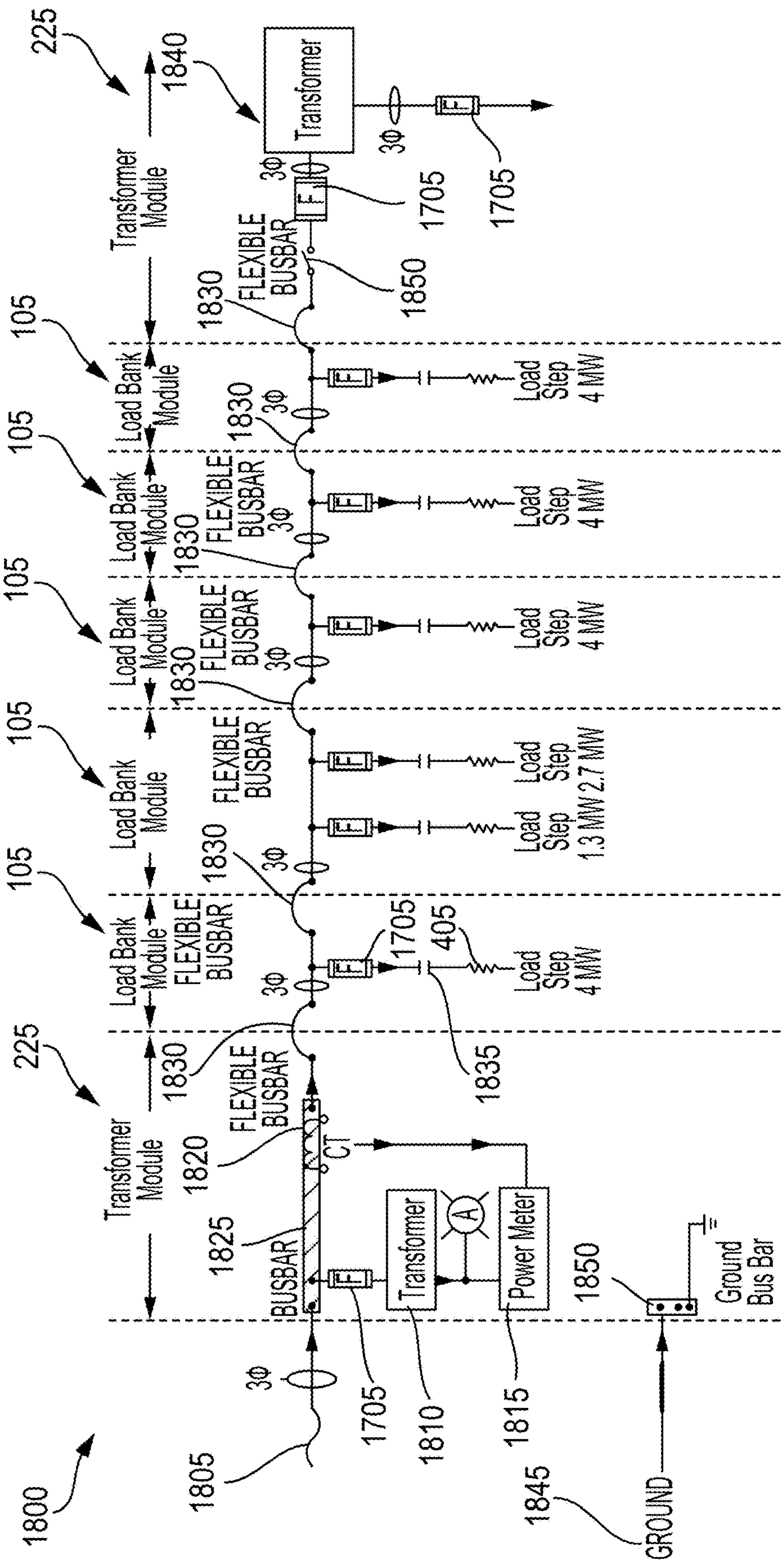

1800
1805
3Φ
1705
1810
1815
1845
GROUND
1850
Ground Bus Bar
Transformer Module
225
BUSBAR
1825
1820
FLEXIBLE BUSBAR
CT
Transformer
A
Power Meter
1830
Load Bank Module
105
FLEXIBLE BUSBAR
1835
405
Load Step 4 MW
Load Step 1.3 MW
Load Step 2.7 MW
1840
1850
Transformer
F

FIG. 19

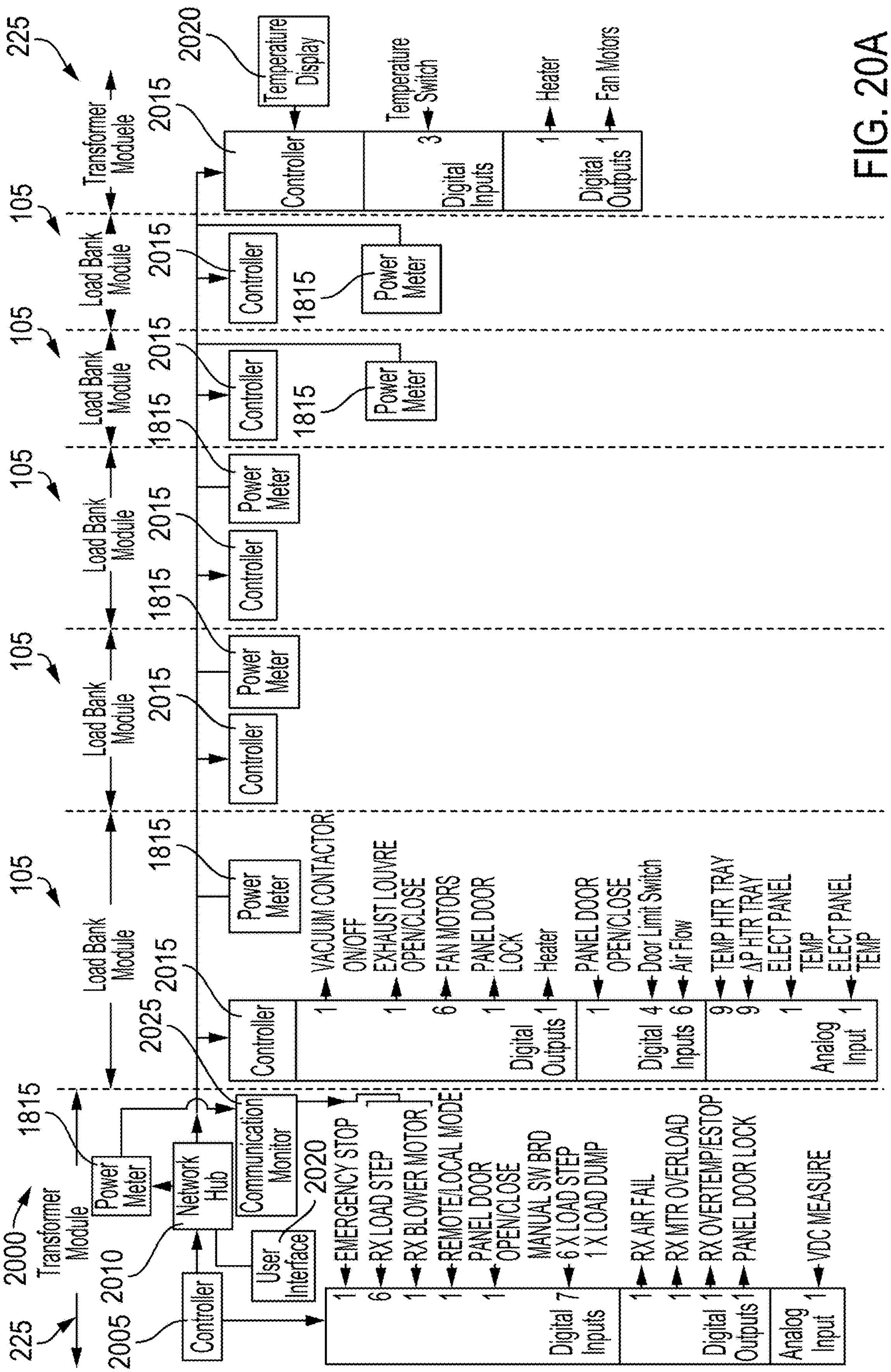

225
2000
Transformer Module
2005
Controller
2010
Network Hub
1815
Power Meter
2025
Communication Monitor
2020
User Interface
Digital Inputs
1 EMERGENCY STOP
6 RX LOAD STEP
1 RX BLOWER MOTOR
1 REMOTE/LOCAL MODE
1 PANEL DOOR OPEN/CLOSE
7 MANUAL SW BRD
6 X LOAD STEP
1 X LOAD DUMP
Digital Outputs
1 RX AIR FAIL
1 RX MTR OVERLOAD
1 RX OVERTEMP/ESTOP
1 PANEL DOOR LOCK
Analog Input
1 VDC MEASURE
105
Load Bank Module
2015
Controller
Digital Outputs
1 VACUUM CONTACTOR ON/OFF
1 EXHAUST LOUVRE OPEN/CLOSE
6 FAN MOTORS
1 PANEL DOOR LOCK
1 Heater
Digital Inputs
1 PANEL DOOR OPEN/CLOSE
4 Door Limit Switch
6 Air Flow
Analog Input
9 TEMP HTR TRAY
9 ΔP HTR TRAY
1 ELECT PANEL TEMP
1 ELECT PANEL TEMP
105
Load Bank Module
2015
Controller
1815
Power Meter
105
Load Bank Module
2015
Controller
1815
Power Meter
105
Load Bank Module
2015
Controller
1815
Power Meter
105
Load Bank Module
2015
Controller
1815
Power Meter
Transformer Moduele
225
2015
Controller
2020
Temperature Display
Digital Inputs
3 Temperature Switch
Digital Outputs
1 Heater
1 Fan Motors

FIG. 20A

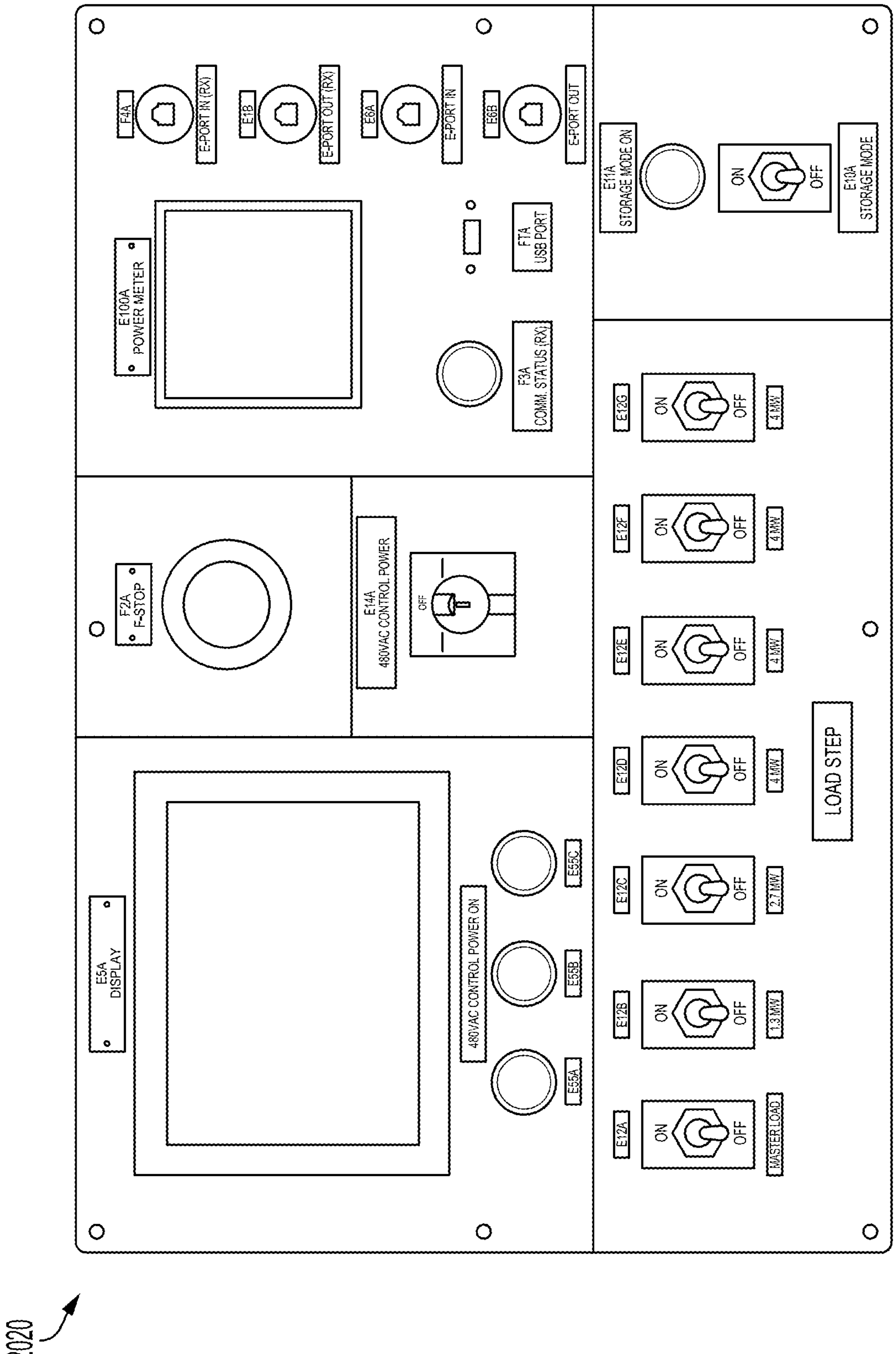

2020
E100A
POWER METER
F4A
E-PORT IN (RX)
E1B
E-PORT OUT (RX)
E6A
E-PORT IN
E6B
E-PORT OUT
FTA
USB PORT
F3A
COMM. STATUS (RX)
E11A
STORAGE MODE ON
ON
OFF
E10A
STORAGE MODE
F2A
F-STOP
E14A
480VAC CONTROL POWER
OFF
E5A
DISPLAY
480VAC CONTROL POWER ON
E55A
E55B
E55C
E12A
MASTER LOAD
E12B
1.3 MW
E12C
2.7 MW
E12D
4 MW
E12E
4 MW
E12F
4 MW
E12G
4 MW
LOAD STEP

FIG. 20B

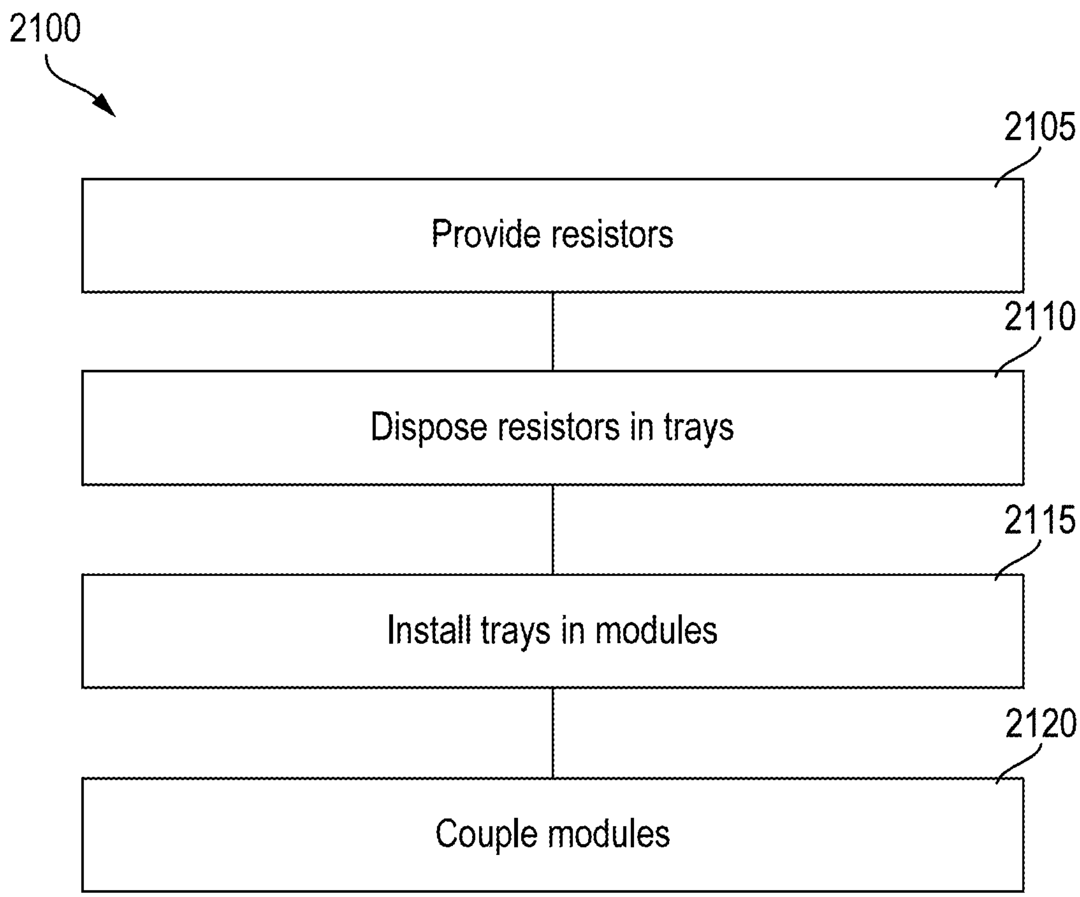

2100
2105
Provide resistors
2110
Dispose resistors in trays
2115
Install trays in modules
2120
Couple modules

FIG. 21

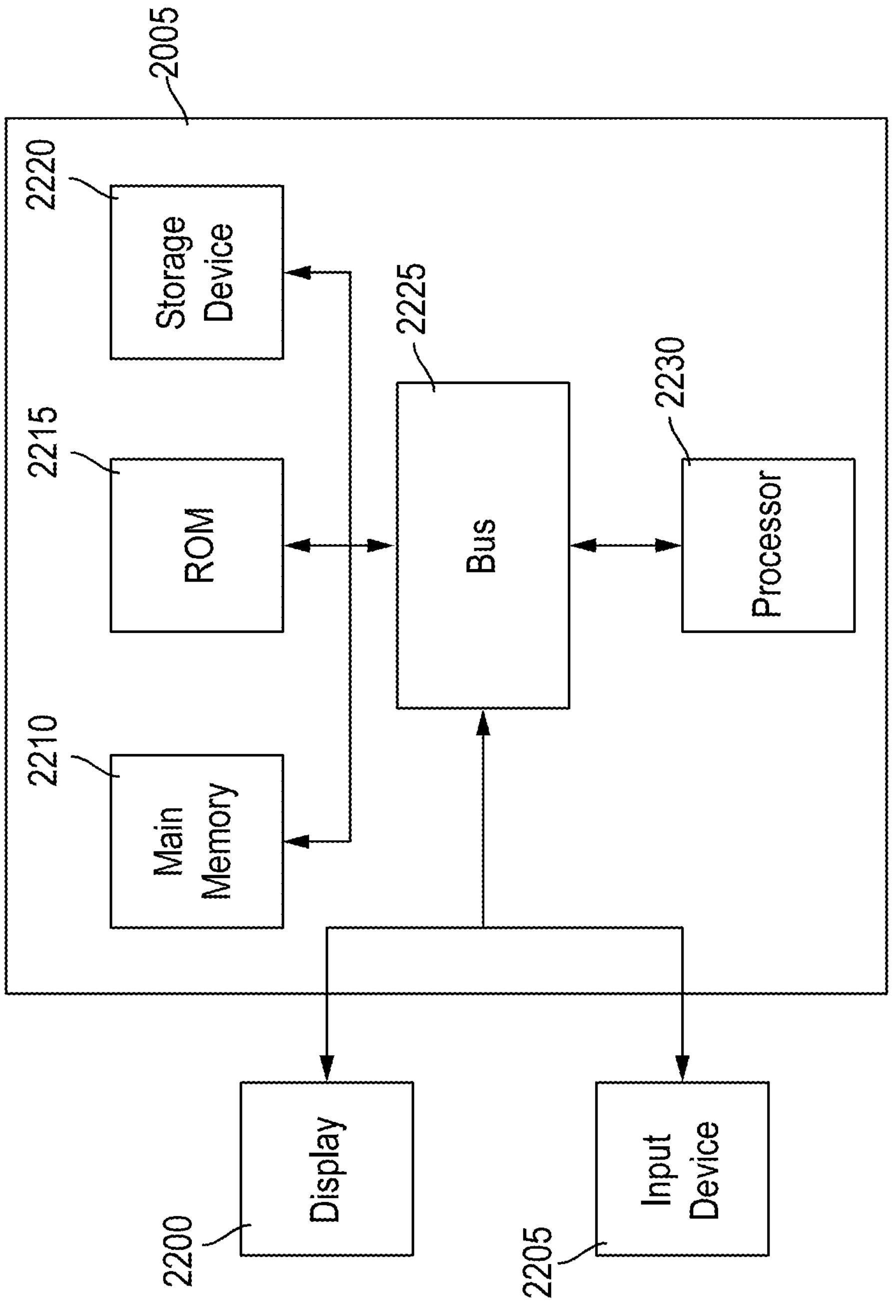

2005
2220
Storage Device
2215
ROM
2210
Main Memory
2225
Bus
2230
Processor
2200
Display
2205
Input Device

FIG. 22

LOAD BANK APPARATUS

CROSS-REFERENCE TO RELATED PATENT APPLICATION

[0001] This application claims the benefit of, and priority to, U.S. Provisional Patent Application No. 63/556,149, filed Feb. 21, 2024, the entirety of which is incorporated by referenced herein.

BACKGROUND

[0002] A load bank can be a system, device, piece of equipment, or apparatus that provides a resistive, inductive, or capacitive load to test a power source. For example, a building, such as a data center, a hospital, a factory, or an airport, can include a power source or backup power source. The power source can be a generator system, a battery system, an uninterruptible power supply, a photovoltaic system, a turbine system, or any other power generating or distribution system, apparatus, or piece of equipment. The load bank can be coupled with the power source to provide a test load that the power source can provide power to. The load bank can be used to load the power source in order to test, adjust, calibrate, or verify the performance of the power source. The load bank can be installed permanently or temporarily at the building, and can be used for periodic testing of the backup power source of the building. Load banks can further be used to test the power sources of aircraft, boats, vehicles or other stationary or moving platforms.

SUMMARY

[0003] At least one aspect of the present disclosure is directed to an apparatus. The apparatus can include a load bank module configured to electrically couple with at least one other load bank module. The load bank module and the at least one other load bank module can be configured to electrically couple to a power source to dissipate power received from the power source. The load bank module can include trays including resistive components to dissipate the power received from the power source at a voltage level of the power source. The trays can removably couple with the load bank module. A resistive component of the resistive components including a coil, the coil extending between a first end of the resistive component and a second end of the resistive component opposite the first end of the resistive component to form three or more turns of the coil.

[0004] The apparatus can include load bank modules including the load bank module and the at least one other load bank module having a total bottom surface area. The total bottom surface area can include a length of 12.3 meters (or 14.63 meters (48 feet)) or less and a width 2.5 meters or less. The load bank modules can be configured to together dissipate at least 20 megawatts (e.g., up to 25 megawatts) of power received from the power source.

[0005] The voltage level can be up to 15,000 volts alternating current or 35,000 volts alternating current.

[0006] The load bank module can have dimensions. The dimensions can include a length of 2.5 meters or 3 meters or less. The dimensions can include a width of 2.5 meters or less. The dimensions can include a height of 2.9 meters or less. The load bank module can be configured to dissipate at least 4 megawatts of power received from the power source.

[0007] The apparatus can include the trays stacked in columns within an enclosure of the load bank module. The trays can electrically coupled together with bus bars. A first set of the trays can couple with a first phase of the power source. A second set of the trays can couple with a second phase of the power source. A third set of the trays coupled with a third phase of the power source.

[0008] The apparatus can further include a first fuse configured to disconnect a first set of the trays from a first phase of the power source responsive to a level of current of the first phase exceeding a first threshold. The apparatus can include a second fuse configured to disconnect a second set of trays from a second phase of the power source responsive to a level of current of the first phase exceeding a second threshold. The apparatus can include a third fuse to configured disconnect a third set of the trays from a third phase of the power source responsive to a level of current of the first phase exceeding a third threshold.

[0009] The load bank module can include lateral sides. At least one of the lateral sides includes a first rail. The trays can include at least one second rail to couple with the first rail for providing a simple way to allow the tray configured to install with the load bank module or to uninstall from the load bank module via the first rail and the second rail.

[0010] The trays can include at least one lateral wall including mica.

[0011] The trays can include a lateral wall that includes openings. The resistive components can be configured to be inserted from a first side of the lateral wall, through the openings, to a second side of the lateral wall.

[0012] The trays can include a lateral wall including a rows of openings from a bottom side of the lateral wall to a top side of the lateral wall, with a first row of the rows of openings offset from a second row of the rows of openings towards a third side of the lateral wall that extends from the top side to the bottom side. The resistive components can be configured to be inserted from a first side of the lateral wall, through the rows of openings, to a second side of the lateral wall.

[0013] The trays can include a lateral wall including openings. The resistive components may be installed within the tray, with bodies of the resistive components that are at least partially disposed on a first side of the lateral wall. At least a portion of the resistive components extend from the first side of the lateral wall, through the openings, to expose terminals of the resistive components on a second side of the lateral wall. The resistive components can include bus bars configured to couple the resistive components via the terminals on the second side of the lateral wall.

[0014] The apparatus can include a resistive component including the coil formed from a wire. The apparatus can include the wire extending back and forth from the first end of the resistive component to the second end of resistive component in a spiral pattern to form turns.

[0015] The resistive component can include a support member having a cylindrical shape, the support member extending from a first end of resistive component to a second end of the resistive component. The resistive component can include discs coupled with the support member and spaced between the first end of the resistive component and the second end of the resistive component. The discs include openings having circular shapes. The resistive component can include a wire extending back and forth from a first end of the resistive component to a second end of resistive through the openings in the discs in a spiral pattern to form turns.

[0016] The load bank module can include a fan apparatus disposed between a bottom of the load bank module and the trays of the load bank module. The fan apparatus can include at least one air guide vane (e.g., directional component) configured to direct an airflow from a first direction ninety degrees to a second direction. The fan apparatus can include blowers configured to pull air from outside the load bank module and the air guide vane to direct the airflow away from the bottom to pass through the trays and cool the resistive components.

[0017] The apparatus can include a tray including a first lateral side and a second lateral side opposite the first lateral side.

[0018] At least one aspect of the present disclosure is a method. The method can include providing a support member having a cylindrical shape. The method can include extending a coil between a first end of the support member to a second end of the support member opposite the first end form three or more turns of the coil. The method can include disposing the resistive component in a tray of multiple trays to dissipate power received from a power source. The method can include disposing the multiple trays in a load bank module.

[0019] The method can include stacking the trays in columns within an enclosure of the load bank module. The method can include coupling a first set of the trays with a first phase of the power source. The method can include coupling a second set of the trays with a second phase of the power source. The method can include coupling a third set of the trays with a third phase of the power source.

[0020] The method can include coupling a first rail with a lateral side of lateral sides of a tray of the trays. The method can include coupling a second rail with a lateral side of lateral sides of the load bank module. The method can include installing or uninstalling, via the first rail and the second rail, the tray with the load bank module.

[0021] The method can include disposing discs on the support member spaced from the first end to the second end. The method disposing a wire in the resistive component by passing the wire back and forth from the first end to the second end through openings in the discs in a spiral pattern to form turns.

[0022] At least one aspect of the present disclosure is directed to an apparatus. The apparatus can include a support member configured to install in, and remove from, a load bank, the support member including a first end and a second side opposite the first end. The apparatus can include a coil to extending between the first end of the support member and the second end of the support member to form turns of the coil.

[0023] The apparatus can include discs coupled with the support member and spaced between the first end of the support member and the second end of the support member, the discs including openings having circular shapes. The apparatus can include a wire extending back and forth from a first side of the support member to a second side of support member through the openings in the discs in a spiral pattern to form turns.

[0024] These and other aspects and implementations are discussed in detail below. The foregoing information and the following detailed description include illustrative examples of various aspects and implementations, and provide an overview or framework for understanding the nature and character of the claimed aspects and implementations. The drawings provide illustration and a further understanding of the various aspects and implementations, and are incorporated in and constitute a part of this specification. The foregoing information and the following detailed description and drawings include illustrative examples and should not be considered as limiting.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] The accompanying drawings are not intended to be drawn to scale. Like reference numbers and designations in the various drawings indicate like elements. For purposes of clarity, not every component may be labeled in every drawing. In the drawings:

[0026] FIG. **1** is an example load bank.

[0027] FIG. **2** is an example load bank mounted on a trailer.

[0028] FIG. **3**A is another example of a load bank mounted on a trailer.

[0029] FIG. **3**B is an example of various numbers of load bank modules coupled together.

[0030] FIG. **3**C is an example of two load bank apparatuses including load bank modules coupled together.

[0031] FIG. **3**D is a front view of an example storage box of a load bank.

[0032] FIG. **3**E is a perspective view of an example storage box of a load bank.

[0033] FIGS. **3**F-**3**G are perspective views of an example transformer module of a load bank.

[0034] FIG. **3**H is a back view of an example transformer module of a load bank.

[0035] FIG. **3**I is a front view of an example transformer module of a load bank.

[0036] FIGS. **3**J and **3**K are cross-sectional views of an example transformer module of a load bank.

[0037] FIG. **4**A is an example disassembled view of a load bank module including trays.

[0038] FIG. **4**B is an example cross-sectional view of the load bank module of FIG. **4**A including trays.

[0039] FIG. **5**A is a front view of an example load bank module including trays.

[0040] FIG. **5**B is an example bottom tray of a first load bank module of a load bank.

[0041] FIG. **5**C is an example bottom tray of a subsequent load bank module coupled with the first load bank of FIG. **5**B.

[0042] FIG. **6** is an disassembled view of a tray including resistive components.

[0043] FIG. **7** is an disassembled view of a tray including support members.

[0044] FIG. **8** is an example view of a tray including bus bars to form a circuit with resistive components.

[0045] FIG. **9** is a cross-section view of a tray including resistive components.

[0046] FIG. **10** is a side view of a tray including rails to install or uninstall from a load bank module.

[0047] FIG. **11** is an example view of a tray where a resistive component couples with a front lateral side of the tray.

[0048] FIG. **12** is an example view of a tray where a resistive component couples with a rear lateral side of the tray.

[0049] FIG. **13** is a rear view of a tray to install with a load bank module.

[0050] FIG. **14** is an example disassembled view of a resistive component including turns.

[0051] FIG. **15**A is an example side view of a resistive component including turns.

[0052] FIG. **15**B is an example wire spiral of a resistive component.

[0053] FIG. **15**C is an example cross-sectional view of the resistive component along cross-section P-P of FIG. **15**A.

[0054] FIG. **15**D is an example cross-sectional view of a resistive component of a load bank along a length of the resistive component.

[0055] FIG. **16**A is a disassembled view of an example fan apparatus.

[0056] FIG. **16**B is a cross-sectional view of the example fan apparatus of FIG. **16**A.

[0057] FIG. **16**C is a front perspective view of an example air guide vane.

[0058] FIG. **16**D is a back perspective view of an example air guide vane.

[0059] FIG. **16**E is a front view of an example air guide vane.

[0060] FIG. **16**F is a side view of an example air guide vane.

[0061] FIG. **16**G is a cross-sectional view of an example air guide vane.

[0062] FIG. **17**A is an example view of a high voltage side of load bank modules including fuses.

[0063] FIG. **17**B is an example view of a low voltage side of load bank modules including columns of trays including resistive components.

[0064] FIG. **18** is an example circuit of load bank modules coupled with a power source.

[0065] FIG. **19** is another example circuit of load bank modules coupled with a power source

[0066] FIG. **20**A is an example circuit of controllers of load bank modules that control the load bank modules.

[0067] FIG. **20**B is an example user interface.

[0068] FIG. **21** is an example method of providing a load bank.

[0069] FIG. **22** is an example computing architecture of a controller.

DETAILED DESCRIPTION

[0070] Following below are more detailed descriptions of various concepts related to, and implementations of, methods, apparatuses, and systems of a load bank apparatus. The various concepts introduced above and discussed in greater detail below may be implemented in any of numerous ways.

[0071] This disclosure is generally directed to a load bank apparatus. A load bank can be used to test, adjust, calibrate, or verify the performance of the power source. A load bank can be configured or rated to dissipate an amount of power from the power source, such as a maximum amount of power, an average amount of power, or a nominal amount of power. To test power source that generate a high amount of power (e.g., tens of megawatts (MW)), the load bank may be configured to dissipate the power in the form of heat via resistive components. While a load bank could be designed or manufactured to include a long length of wire for resistive heating components to dissipate a high amount of power, the load bank may be very large and heavy. Manufacturing, shipping, delivering, or storing a large load bank can be technically difficult and consume large amounts of resources. Furthermore, a load bank can be difficult to troubleshoot or repair. If individual components of the load bank malfunction or need servicing, it can be difficult for a technician to identify the component requiring servicing, access the component, and replace the component.

[0072] Furthermore, it can be difficult to have proper electrical insulation and isolation for a load bank with voltages up to 15,000 volts or 33,000 volts in a compact or small space. The high voltages and high amount of power dissipated can further cause high internal temperatures within a load bank, up to 400 degrees Celsius. This high amount of heat can cause structural challenges for resistive heaters and/or other structural components of the load bank.

[0073] To solve these, and other technical problems, technical solutions of this disclosure can include a load bank apparatus that can be modular and can operate at a high voltage. The load bank can be a system, apparatus, or piece or set of equipment. The modular load bank can include multiple load bank modules. Each load bank module can include a set of trays. Each tray can include a set of resistive component cartridges. The load bank modules, the trays, and the resistive components can efficiently utilize space to allow for high power dissipation (e.g., 10-20 megawatts (MW), 20 MW or more, less than 10 MW, greater than 7 MW) in a small foot print (e.g., a total bottom surface area with a length 12-13 meters and a width of 2-3 meters and a height of 2.9-3.1 meters). The modular load bank can be fit on a standard sized 40 foot or 48 foot trailer bed (12.2 meter or 14.63 meter trailer bed), which can have a length of 504 inches (12.8 meters) and a width of 102 inches (2.6 meters). In some implementations, load bank modules can be packaged or enclosed in a storage or shipping container. The storage or shipping container can range in size, for example, from 8 feet to 53 feet in length (e.g., 2.4-16.2 meters) with a width of 96 inches (e.g., 2.4-2.5 meters) and a height of 102 inches (e.g., 2.5-2.6 meters) or 120 inches (e.g., 3.0-3.1 meters).

[0074] The modular load bank can include resistive components that efficiently utilize space to dissipate a high amount of power in a low amount of space. This efficient use of space can allow the load bank to operate efficiently to dissipate power and heat, and directly operate on high voltage (e.g., 13,800-33,000 volts), without requiring a step down transformer or a larger enclosure for the load bank. Not requiring a step down transformer can save space and weight. A load bank might include a step down transformer to transform voltage from a source voltage (e.g., 13,800 volts) to a voltage for the load bank resistive components to operate on, e.g., 480 volts. However, the present load bank's resistive components can be coupled directly to the source voltage (e.g., three phases of 13,800 volts or up to 33,000 volts). Furthermore, the efficiency of the load bank can result in a weight of only 25 tons for 20,000 kW at a direct source voltage of 13,800 volts, which may be approximately 20% lighter than other 20,000 kW load banks. Because the enclosure size for the load bank can be kept small, the load bank can be fit on a smaller platform, such as the standard 40 foot trailer bed, and still dissipate a high amount of power, such as 20 MW or more. For example, the resistive components of the module load bank can be formed to include multiple turns of coiled or a spiral patterned wire. The resistive components can include turns or lengths of the coiled wire from a first end of the resistive component to a second end of the component, e.g., 4-13 turns. With the spiral pattern and 11-13 turns of wire, approximately 11 meters of wire can be fit into a cylindrical shaped cartridge approximately 1.3 meters long with a 1-3 inch (2.5-7.6 centimeters) diameter. The resistive components can be cartridge based components that can be installed or removed from a tray. This can allow for efficient access or servicing of the load bank apparatus.

[0075] The load bank modules can include trays in which resistive components are installed. The trays can include a housing shaped in a rectangular solid shape, cube shape, or any other shape. The resistive components can be removably coupled with the trays. For example, the resistive components can be inserted through openings in a lateral wall in the tray into a body, cavity, or interior of the tray. The resistive components can include terminals that extend past the openings in the housing. Bus bars can be coupled with the terminals to wire the resistive components together and electrically couple the resistive components to the power source to dissipate power. In this regard, the trays can form a circuit board or wiring board where resistive component cartridges can be installed and then wired together.

[0076] The trays can be stacked into multiple columns or rows to form a set or matrix of trays. The trays can be stacked within a load bank module. The load bank module can include a housing that stores, at least partially encloses, includes, or contains the trays and resistive component cartridges. The load bank modules can be wired or coupled together via bus bars, such as flexible bus bar. The load bank modules can be wired in parallel with each other and the power source. The load bank modules can be electrically coupled with the power source to load the power source and dissipate power.

[0077] The resistive components can be organized or disposed in trays, which can be organized or disposed in load bank modules such that heat is efficiently dissipated. The load bank apparatus can include blowers that pull air in from outside the load bank, pass the air upwards through the load bank, and carry heat out of openings in the top of the load bank. In this regard, even if high internal temperatures are reached, such as 400 degrees Celsius, the load bank can still have structural integrity when undergoing high mechanical stress.

[0078] Referring now to FIG. **1**, among others, an example load bank **100** is shown. The load bank **100** can be an apparatus, a system, or a group or set of components or pieces of equipment. The load bank **100** can be electrically coupled with a power source, such as the power source of a building, vehicle, or other stationary or mobile platform. The load bank **100** can provide a load for the power source. The power source can be a generator system, a battery system, an uninterruptible power supply, a photovoltaic system, a turbine system, or any other power generating system, apparatus, or piece of equipment. The load bank **100** can include at least one load bank module **105**. The load bank module **105** can be an apparatus, a system, cabinet, a piece of equipment, or a device. The load bank **100** can include one to six load bank modules **105**. According to another exemplary embodiment, the load bank **100** can include at least two load bank modules **105**. According to another exemplary embodiment, the load bank **100** can include five load bank modules **105**. According to still other exemplary embodiments, the load bank **100** can include at least five load bank modules **105**. The load bank **100** can have a maximum rated load bank capacity of 4, 8, 16, 20, or 24 MW. The physical size of the containers or enclosures of the load bank **100** can depend on the maximum rating of the load bank **100**. For example, a 20 MW rated capacity for a load bank **100** can include a container of at least 40 feet in length. For a load bank capacity over 20 or 24 MW, the load bank **100** can include a container of 50 or 53 feet in length.

[0079] The load bank **100** can have a resolution, for example, a standard 1,333 kW resolution. In some implementations, the load bank **100** can have a resolution of 20 kW, 40 kW, 80 kW, 160 kW, 320 kW, 640 kW, or any other resolution. The physical size and dimensions of the containers or enclosures of the load bank module **105** can be adapted to provide higher or lower resolution, depending on the resolution selected for the load bank **100**.

[0080] The load bank modules **105** can be electrically coupled together. For example, a load bank module **105** can be electrically coupled with at least one other load bank module **105**, or all or a subset of the other load bank modules **105** of the load bank **100**. The load bank modules **105** can be directly or indirectly electrically coupled with the power source to receive power from the power source and dissipate the power. The load bank modules **105**, via resistive components, can dissipate the power by converting the power to heat. Each load bank module **105** can dissipate an amount of power, 3.5 MW to 4.5 MW, 3 MW to 5 MW, less than 3 MW, more than 5 MW, or 1 MW to 5.6 MW. Each load bank module **105** can dissipate substantially 4 MW. Each load bank module **105** can dissipate at least 4 MW. The load bank module **105** can have a length of 2.5 meters or 3 meters or less. For example, the load bank module **105** can have a length of 2.3-2.7 meters. The length of the load bank module **105** can be 2-3 meters. The length of the load bank module **105** can be less than 2 meters. The length of the load bank module **105** can be greater than 3 meters. The load bank module **105** can have a width of 2.5 meters or less (e.g., 96-102 inches or less). For example, the load bank module **105** can have a width of 2.4-2.6 meters. The width of the load bank module **105** can be 2.3-2.7 meters. The width of the load bank module **105** can be less than 2.3 meters. The width of the load bank module **105** can be greater than 2.7 meters. The load bank module **105** can have a height of 2.9 meters or less (e.g., 114 inches or less). For example, the load bank module **105** can have a height of 2.8-3.0 meters. The height of the load bank module **105** can be 2.7-3.1 meters. The height of the load bank module **105** can be less than 2.7 meters. The height of the load bank module **105** can be greater than 3.1 meters. The load bank modules **105** can be wired or coupled together to dissipate a total amount of power. For example, the load bank **100** can dissipate 18-22 MW, 17-23 MW, less than 17 MW, or more than 23 MW. The load bank **100** can dissipate approximately 20 MW. The load bank **100** can dissipate at least 20 MW of power. The load bank **100** can have a capacity to dissipate up to 50 MW of power.

[0081] The load bank module **105** can include a housing **115**. The housing can include lateral sides, e.g., a first lateral side, a second lateral side, a third lateral side, a fourth lateral side, a top side, a bottom side. The housing **115** can form a rectangular solid, a cube, a prismatic shape, or any other shape. The housing **115** can be formed from aluminum or steel. A top side of **120** of the load bank can include an opening **125**. The opening **125** can allow air heated by resistive components disposed within the load bank module

105 to exit the housing of the load bank module **105**. The load bank modules **105** can include louvers **145**. The louvers **145** can be coupled with edges or surfaces of the top side **120**. The louvers **145** can open or close. The louvers **145** can be operated by a manual lever. The louvers **145** can move between a first position, a second position, and a third position. The louvers **145** can move to a closed position to limit an airflow through the opening **125**. The louvers **145** can move to open positions to allow or increase an airflow through the opening **125**. The louvers **145** can move to a defrost position where the louvers **145** are partially opened (e.g., approximately 5 degrees open). The louvers **145** can rotate, turn, or move on hinges or hinging apparatuses.

[0082] The load bank module **105** can include computer systems, displays, or user interfaces for interacting with or controlling the load bank modules **105**. The power source can be electrically coupled with the load bank **100** via a transformer module **125** (shown in FIG. **2**). The load bank **100** can have a total footprint or total bottom surface area. The total bottom surface area can have a length **130** and a width **135**. The load bank **100** can have a length **130**. The length **130** can be 12.1-12.4 meters long. The length **130** can be 12-12.5 meters long. The length **130** can be less than 12 meters long. The length **130** can be greater than 12.5 meters long. The length **130** can be 12.3 meters or less. The length **130** can be 14.63 meters (48 feet) or less. The length can be approximately 480 inches (12192 millimeters). The width **135** can be 2.4-2.6 meters. The width **135** can be 2.3-2.7 meters. The width **135** can be less than 2.3 meters. The width **135** can be greater than 2.7 meters. The width can be 2.5 meters or less. The width can be approximately 102 inches (2591 millimeters). The load bank **100** can have a height **140**. The height **140** can be 2.8-3.0 meters. The height **140** can be 2.7-3.1 meters. The height **140** can be less than 2.7 meters. The height **140** can be greater than 3.1 meters. The height **140** can be approximately 114 inches (2896 millimeters). Each load bank module **105** can dissipate a high amount of power, e.g., 4,000 kW in a small area, e.g., an 8 foot wide and 9 foot high volume for a high voltage, e.g., 13,800 volts AC. Overall, the load bank **100** can dissipate 20,000 kilowatts at 13,800 volts in a 40 foot wide and 8 foot high volume.

[0083] Referring now to FIGS. **2-3**A, among others, the load bank **100** is illustrated mounted on a trailer **200**. The trailer **200** can be any type of trailer, such as a two or three axel trailer or a drop deck trailer. The trailer **200** can be or include a flat surface that the load bank **100** can rest on and be supported by. The trailer **200** can include any platform, deck, apparatus, or vehicle that includes a platform to carry the load bank **100**. The load bank **100** can be sized to fit on or within outer boundaries of the trailer **200**. The load bank modules **105** can be disposed on a rear portion **210** of the trailer **200**. The rear portion **210** can be a trailer deck, a main trailer deck, or a rear trailer deck. The rear portion can have a length **215** and a width **220**. The length **215** can be 12.7-12.8 meters. The length **215** can be 12.6-12.9 meters. The length **215** can be less than 12.6 meters. The length **215** can be greater than 12.9 meters. The length **215** can be approximately 42 feet (43,282 millimeters). The rear portion **210** can have a width **220**. The width **220** can be 2.4-2.6 meters. The width **220** can be 2.3-2.7 meters. The width **220** can be less than 2.3 meters. The width **220** can be greater than 2.7 meters. The load bank **100** can be transportable by the trailer **200** as one assembly or package (instead of in multiple separate assemblies or packages), e.g., can meet DOT USA transportation requirements such as height restrictions.

[0084] The trailer **200** can include an upper deck **205**. The upper deck **205** can be coupled, attached, or connected to the lower deck **210**. Containers or assemblies for the load bank **100** can be installed on the lower deck **210**, while a transformer package can be installed on the upper deck **205**. A transformer system, apparatus, or module **225** can fit or be disposed with an area, space, or section of the upper deck **205**. The transformer module **225** can provide a low voltage for internal power control. The power provided to the load bank modules **105** can be high voltage (e.g., 13,800-15,000 volts or up to 33,000 volts), and may not be stepped down by the transformer module **225**, or any other transformer. Because the load bank modules **105** can include trays including mica walls, resistive cartridges with long distances of coils of thin long wire formed into turns, and/or efficient cooling airflow, the load bank modules **105** can be rated for high voltages, and can couple directly with the high voltage of power sources, without requiring any step down transformer. The transformer module **225** can have a bottom surface area that fits on or within an outer boundary of the upper deck **205**. The upper deck **205** can have a length **230**. The length **230** can be 2.5-2.6 meters long. The length **230** can be 2.4-2.7 meters long. The length **230** can be less than 2.4 meters. The length **230** can be greater than 2.7 meters long. The length **230** can be approximately 2591 millimeters long (102 inches). The upper deck **205** can have a width of **220**. Furthermore, a storage box **235** can be disposed on the upper deck **205** along with the transformer module **225**. In some embodiments, the load bank modules **105** can provide 15 MW, 8 MW, or 5 MW at 33,000 volts, which can be used for a 40 foot, 30 foot, or 20 foot container. In some embodiments, the load bank **100** can be a 48 foot (14.63 meter) 24 MW load bank with a transformer module **225**. In some embodiments, the load bank **100** can be a 48 foot (14.63 meter) 20 MW load bank without a transformer module **225**.

[0085] In some implementations, the load bank **100** can be installed on a surface other than the decks **205** and **210** of the trailer **200**. For example, the load bank **100** can be installed on the ground. For example, the load bank **100** can be installed on a concrete surface, a reinforced concrete surface, an asphalt surface, or a gravel surface. The load bank **100** can be installed in a parking lot, in a specialized load bank area, or in any other location next to or near a building or campus.

[0086] Referring now to FIG. **3**B, among others, examples of various numbers of load bank modules coupled together are shown. FIG. **3**B depicts load banks **300-325**. The load banks **300-325** can include different numbers of load bank modules **105**. The load bank modules **105** can be coupled together via one set of bus bars. The load bank modules **105** can be coupled with a continuous or common bus bar that runs a length of the load bank. The load bank modules **105** can be coupled on the same electrical bus. Jumpers can couple multiple load banks with the continuous bus bar.

[0087] The load bank modules **105** can be daisy chained together. For example, load bank **300** can include a single load bank module **105** and a transformer module **225**. The load bank **305** can include two load bank modules **105**. The load bank **310** can include three load bank modules **105**. The load bank **315** can include four load bank modules **105**. The load bank **320** can include five load bank modules **105**. The load bank **325** can include six load bank modules **105**. In some implementations, a load bank can include more than six load bank modules **105**.

[0088] Referring now to FIG. **3**C, among others, an example of two load bank apparatuses **325** including load bank modules **105** coupled together is shown. The load bank **100** can be modular, and can be formed from load bank modules **105** rated up to 4 MW. For example, load bank modules **105** can be packaged as one assembly in a group of load bank modules **105** (e.g., 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12 load bank modules **105** for power ratings of up to 4, 8, 12, 16, 20, 24, or up to 48 MW) in a container of a length up to 53 feet, or two containers of 53 feet. The load bank **100** can include 1 to 6 load bank modules **105**, in some embodiments. To prove a capacity over 20 MW or 24 MW, two load bank containers can be installed on a common base, with a common electrical power bus (e.g., 14 kV bus) for incoming power for the load banks. The containers can be 40 or 50 feet long, or as long as needed.

[0089] Each load bank apparatus **325** can be mounted on an independent platform **340**, or on one single platform **340**. Each load bank module **105** can be rated to dissipate 1-5.6 MW. The load bank container assembly can be installed in various configurations, such as on a 40 foot flatbed trailer truck, or in a 40 foot container on the ground with riser blocks. In some implementations, multiple load bank modules **105** can be packed on a single common base or frame **340** as one assembly **325**. In this regard, the multiple load bank modules **105** can provide up to 33.6 MW. Similarly, if two assemblies **325** are daisy chained together, the two assemblies could provide a total of 67.2 MW. The load bank apparatuses **325** can be elevated above a floor or surface. For example, the platforms **340** can be raised a distance **350** a minimum of 10 inches from the floor, and a maximum of 15 inches from the floor via one or more supports or riser blocks. In some implementations, the riser blocks or other suitable structure can raise the load bank **100** off the ground. For example, the riser blocks can provide elevation of 24 to 40 inches. The elevation provided by the riser blocks can prevent the load bank modules **105** from being exposed to ground water that rises to a high level. In some implementations, the ground that the load bank modules **105** are installed above can be of a suitable material, such as concrete, to support up to 45,000 pounds of weight, while maintaining the load bank modules **105** in a level position. For example, the surface that the load bank modules **105** are installed on can be 8 inches thick reinforced cement concrete (RCC).

[0090] The load bank apparatuses **325** can be disposed in a row, and coupled together on at least one continuous bus bar. Each load bank apparatus **325** can include a number of load bank modules **105**. Each load bank apparatus **325** can have a length **330**. The length **330** can be 50 feet, and therefore the total length **345** of the load bank apparatuses **325** can be 100 feet. The length **330** can be 15.2-15.3 meters. The length can be 15.1-15.4 meters. The length can be less than 15.1 meters. The length can be more than 15.4 meters.

[0091] Referring now to FIGS. **3**D-**3**E, the storage box **235** is shown in greater detail. The storage box **235** can include one or multiple compartments covered by doors **355**. For example, the storage box **235** can include a stacked column of two or more compartments covered by doors **355**. The compartments of the storage box **235** can store equipment, tools, space parts, or any other component or device for the load bank **100**. The storage box **235** can be sized to fit along with the transformer module **225** on the upper deck **205**. The storage box can have a width **360**. The width **360** can be approximately 711 millimeters. The width **360** can be 700-720 millimeters. The width **360** can be 680-740 millimeters. The width **360** can be less than 680 millimeters. The width **360** can be greater than 740 millimeters. The storage box **235** can include a height **365** of approximately 1572 millimeters. The height **365** can be 1560-1580 millimeters. The height **365** can be 1550-1590 millimeters. The height **365** can be less than 1550 millimeters. The height **365** can be greater than 1590 millimeters. The length **373** can be approximately 2438 millimeters. The length **373** can be 2430-2450 millimeters. The length **373** can be 2420-2460 millimeters. The length **373** can be less than 2420 millimeters. The length **373** can be greater than 2460 millimeters.

[0092] Referring now to FIGS. **3**F-**3**K, the transformer module **225** is shown, according to an exemplary embodiment. The transformer module **225** can have a box or prismatic shaped enclosure. The enclosure of the transformer module **225** can have a sloped surface **370** including a door **375**. The sloped surface **370** can include at least one opening covered by the door **375**, and at least one opening for cables **380**. The cables **380** can be various phases of an AC power source (e.g., a building, a campus, a vehicle, a plane, etc.). The cables **380** can be guided to the enclosure of the transformer module **225** via at least one cable guide **385**. The cable guide **385** can be a ladder or cage. The cable guide **385** can include members **390**. For example, the cable guide **385** can include two parallel members that are hung from brackets **395** coupled with the enclosure of the transformer module **225**. Each parallel member **390** can be coupled to the enclosure of the transformer module **225** via a bracket **395**. The parallel members **390** can be coupled with the brackets **395** via a hinge, and can rotate about the bracket **395**. The cable guide **385** can include members **390** extending between the parallel members **390**.

[0093] The transformer module **225** can include at least one curtain **397**. The curtain **397** can be formed from rubber, plastic, or any non-conductive material. The curtain **397** can be hung or disposed from a bottom edge of the door **375**, and can cover or partially cover the cables **380** where the cables enter into the enclosure of the transformer module **225**. The curtain **397** can be segmented into portions or flaps such that some flaps can be flush with a bottom of the side **370**, and other flaps can be raised to allow a cable **380** to enter into the enclosure of the transformer module **225**. FIGS. **3**J-**3**K depict a cross-sectional view of the transformer module **225** taken along the cross-section H-H of FIG. **3**H, illustrating the cables **380** guided into the enclosure of the transformer module **225** by the cable guide **390**.

[0094] Referring now to FIGS. **4**A-B, among others, an example disassembled view of load bank module **105** including heater trays **405** is shown. The load bank module **105** can include at least one system, device, apparatus, cabinet, heater tray, or tray **405**. The load bank module **105** can include multiple trays **405** disposed, contained, included, or positioned within a housing **410** of the load bank module **105**. The housing **410** can have a prismatic shape, a rectangular shape, or a cube shape. The housing **410** can form an open space, an area, or a cavity. The housing **410** can be made from or include steel, aluminum, tungsten, or any other material. The housing **410** can include lateral sides **415** that form the inner space of the load bank module **105**. The lateral sides **415** can be top sides, bottom sides, or lateral sides. The lateral sides **415** can form inner sides, e.g., within a cavity or space of the load bank module **105**. The trays **405** can sustain operating temperatures at the four vertical walls of the trays **405** up to 500-600 degrees Celsius. The four vertical walls of the trays **405** can be rated up to 15,000 volts or 33,000 volts. The trays **405** can provide continuous guided support for a resistor cartridge to be removed, e.g., pulled out, and re-inserted, e.g., pushed in. In some implementations, the trays **405** can be completely removed or uninstalled, while the resistor cartridges are fully supported and remain fixed to the trays **405**. Similarly, a tray **405** of resistor cartridges can be installed in the load bank module **105**, a first tray **405** can be removed and another tray **405** can be inserted into the load bank module **105** to replace the first tray.

[0095] The trays **405** can be organized in columns, one stacked over another. The trays **405** can be physically stacked on one another, or can be stacked over each other with spaces in between the trays **405**. The trays **405** can be stacked in one, two, three, or more columns. The trays **405** can be organized in a matrix, with columns and rows of trays **405**. The trays **405** can be stacked in columns for individual phases. For example, a first column of trays **405** can be coupled with a first phase of a power source, a second column of trays **405** can be coupled with a second phase of the power source, and a third column of trays **405** can be coupled with a third phase of the power source. The trays **405** can include resistive components or cartridges. Each cartridge can dissipate energy in the form of heat to provide a load for a particular tray **405** that the load bank **100** provides for a power source.

[0096] The load bank module **105** can be electrically coupled with at least one other load bank module **105** and/or the power source via bus bars **420**. The bus bars **420** can be electrically coupled with the resistive components **535** of the trays **405**. The bus bars **420** can be electrically coupled with another load bank module **105**. The bus bars **420** can be electrically coupled with a power source. A first load bank module **105** can be electrically coupled with a power source through or via an electrical coupling with a second load bank module **105** via the bus bars **420**. The load bank module **105** can include multiple bus bars **420** for multiple different phases of an alternative current (AC) power source. For example, the load bank module **105** can include a first bus bar **420** to couple with a first phase of the power source, a second bus bar **420** to couple with a second phase of the power source, and a third bus bar **420** to couple with a third phase of the power source. The bus bars **420** can include a neutral bus bar **450** and at least one flexible bus bar **455**. Furthermore, the load bank module **105** can include at least one cable **463** to fuses **1705**, e.g., at least one wire for each phase A, B, and C and neutral. The load bank module **105** can include a cover **475** over all bus bars, jumpers, connections, etc.

[0097] The load bank module **105** can include at least one door **425**. The door **425** can open outwards away from the inner space of the load bank module **105** to expose an opening **435** into the load bank module **105**. The opening **435** can be formed from ends of lateral, top, and bottom sides **415**. The doors **425** can be coupled to opposite lateral sides **415** via a hinging component to rotate the doors **425** between closed and open positions.

[0098] The load bank module **105** can include a rear opening opposite the opening **435**. The rear opening can be covered by doors **425**. The doors **425** covering the rear opening can open opposite the doors **425** covering the opening **435**. The load bank module **105** can include sheets **445**. The sheets **445** can be disposed across the rear opening between the lateral sides **415** and the doors **425**. The sheets **445** can be made of polycarbonate and can be clear or transparent. The load bank module **105** can include panels. The panels can be electrical panels that cover or secure electrical components or systems of the loads bank module **105**. The load bank module **105** can include sheets that can be made or formed from mica, and be disposed on an inner side of the sheet **445**.

[0099] The trays **405** can include connectors **460**. The connectors **460** can be disposed on an outer side **465** of the trays **405**. The connectors **460** can extend from a first end or front of the tray **405** to a second end or rear of the tray **405**. The connectors **460** can be rails, snaps, slides, or other components that couple the trays **405** to the lateral sides **415**. The lateral sides **415** of the housing **410** can include connectors. The connectors **460** of the trays **405** can couple with connections of the lateral sides **415**. The connectors **460** and connectors of the lateral sides **415** can couple, e.g., one rail coupling onto or over another rail. The connector **460** can move on or slide on the connector. The inner surfaces of the lateral sides **415** of the housing **410** can include connectors. The outer surfaces of the lateral sides **415** disposed within the housing **410** can include connectors.

[0100] The trays **405** can removably couple with the load bank modules **105**. The trays **405** can couple or de-couple from the load bank **105**. The trays **405** can install from an outer side of the housing **410** into the housing **410**. The connectors **460** can be connected with the connectors of the lateral side **415** and installed into the housing **410**. The trays **405** can install with the housing **410**. The trays **405** can be connected, from an outer side of the housing **410**, to the connectors of the lateral sides **415** and pushed into or through the opening **435** into the housing **410**. The trays **405** can be pulled out of the load bank module **105** on the connectors **460**. For example, rails **460** can be mounted onto rails coupled to the lateral sides **415** of the housing **410**, and the trays **405** can slide into or out of the housing **410**. The trays **405** can be installed into the housing **410** by passing the trays **405** from an outer side of the housing **410**, through the opening **435**, and into the housing **410**. The trays **405** can be uninstalled from the housing **410**, from an inner side of the housing **410**, through the opening **435**, and out of the housing **410**.

[0101] Referring now to FIG. **5**A, among others, an example load bank module **105** including trays **405** is shown. The load bank module **105** can be wired via bus bars. For example, the load bank module **105** can include ground or neutral bus bars **505**. The neutral bus bars **505** can provide a current return path to the power source. The bus bars **505** can run horizontally along a top of the load bank module **105**. The bus bar **505** can extend perpendicular to the first lateral side **415** or the second lateral side **415**. The bus bar **505** can extend parallel to a top side **415** of the housing **410**.

[0102] Vertical bus bars **540** can extend from the horizontal bus bars **505** downwards towards a bottom side **415** of the housing **410**. The horizontal bus bar **505** and the vertical bus bars **540** can be coupled together via a bolt or screw and be in an electrical connection. The horizontal bus bars **505** and the vertical bus bars **540** can be integrally formed. The vertical bus bars **540** can extend downwards away from the horizontal bus bar **505** towards the bottom side **415**. The vertical bus bars **540** can extend downwards towards a bottom row of trays **405**. Bus bar portions **545** can extend perpendicularly from vertical bus bars **505** across a face of the trays **405**. The bus bar portions **545** can be parallel with the horizontal bus bars **505** or the face of the trays **405**. The bus bar portion **545** can be coupled with terminals **525** of resistive components **535** of the trays **405**. The resistive components **535** can be electrical resistors that dissipate power received from the power source.

[0103] The resistive components **535** in a particular load bank module **105** can collectively dissipate 1 MW to 5.6 MW. Together, the resistive components **535** of multiple load bank modules **105** can dissipate up to 33.6 MW in an assembly where multiple load bank modules **105** are packed on one frame as one assembly. The resistive components **535** can collectively dissipate up to 67.2 MW in a system where two load bank assemblies are daisy chained together. The resistive components **535** of each load bank module **105** can collectively dissipate an amount of power, 3.5 MW to 4.5 MW, 3 MW to 5 MW, less than 3 MW, more than 5 MW, 1 MW to 5.6 MW, etc. The resistive components **535** of each load bank module **105** can collectively dissipate substantially 4 MW. The resistive components **535** of each load bank module **105** can collectively dissipate at least 4 MW. The resistive components **535** can each individually dissipate 18-20 kW. The resistive components **535** can each dissipate 17-20 kW. The resistive components **535** can each individually dissipate less than 17 kW. The resistive components **535** can each individually dissipate more than 20 kW. The power rating for the resistive components **535** can be configurable for different voltage ratings in the ranges of 480 to 15,000 volts or 480 to 33,000 volts. The resistive components **535** can have different steps as a single coil resistor value, or up to six steps. The surface operating temperature of the resistive components **535** can be up to 1,000 degrees Celsius.

[0104] The bus bar portions **545** can extend across a row of a resistive components **535** in one tray **405**. The bus bar portion **505** can extend across a top row, middle row, or bottom row of resistive components **535** of a tray **405**. The resistive components **535** can have a power density of 7-7.8 kW/ft^3. The resistive components **535** can have a power density of 6.8-8 kW/ft^3. The resistive components **535** can have a power density of less than 6.8 kW/ft^3. The resistive components **535** can have a power density of greater than 8 kW/ft^3. The resistive components **535** can provide 0.4-0.7 kW/lb. The resistive components **535** can provide 0.3-0.8 kW/lb. The resistive components **535** can provide less than 0.3 kW/lb. The resistive components **535** can provide more than 0.8 kW/lb.

[0105] In FIG. **5**A, the bus bar portions **505** can extend across a top row of resistive components **535** for top and bottom rows of the trays **405**. Because the horizontal bus bar **505**, the vertical bus bar **540**, and the bus bar portion **545** are electrically coupled with each other, the resistive components **535** can be electrically coupled to a neutral connection.

[0106] The bus bars **510**, **515**, and **520** can be electrically coupled to different phases of a power source. For example, the bus bar **510** can be coupled to a first phase of the power source, the bus bar **515** can be electrically coupled with a second phase of the power source, and the bus bar **520** can be electrically coupled with a third phase of the power source. The bus bars **510**, **515**, and **520** can be horizontal or parallel with the top side **415**, the bottom side **415**, or the horizontal bus bars **505**. Each phase can be 40-1,600 amperes (at 33,000 volts to 480 volts for 1.3 MW).

[0107] The bus bar **510** can extend across a row of resistive components **535**. For example, the bus bar **510** can extend over a bottom row of resistive components **535** of a bottom tray **405** of a first or leftmost column of trays **405**. The bus bar **510** can be electrically coupled with terminals **525** of the row of resistive components **535**. The bus bar **515** can extend across a row of resistive components **535**. For example, the bus bar **515** can extend over a bottom row of resistive components **535** of a bottom tray **405** of a second or middle column of trays **405**. The bus bar **515** can be electrically coupled with terminals **525** of the row of resistive components **535**. The bus bar **520** can extend across a row of resistive components **535**. For example, the bus bar **520** can extend over a bottom row of resistive components **535** of a bottom tray **405** of a third or rightmost column of trays **405**. The bus bar **530** can be electrically coupled with terminals **525** of the row of resistive components **535**. Vertical bus bars **550** can extend from each respective bus bar **510**, **515**, and **520**. Horizontal bus bars **555** can extend horizontally from each vertical bus bar **550** to couple with terminals **525** of a row of resistive components **535** in each tray **405**.

[0108] In FIG. **5**A, the trays **405** of each respective column of trays **405** can be coupled in parallel. The trays **405** of a first column can be coupled in parallel with each other. The trays **405** of a second column can be coupled in parallel with each other. The trays **405** of a third column can be coupled in parallel with each other. In each tray **405**, the resistive components **535** can be coupled in parallel and in series via bus bars **530**. Each column of resistive components **535** in a particular tray **405** can be connected in series, while each column of resistive components **535** in the particular tray **405** can be coupled in parallel with each other column of resistive components **535**. Each column of resistive components **535** can be electrically coupled between a bus bar coupled with a first phase of the power source to a bus bar coupled with a neutral of the power source.

[0109] Each column of trays **405** can include at least one temperature sensor and/or pressure sensor at the top of the column (e.g., near the exhaust louvers **145**) and at least one temperature and/or pressure sensor at the bottom of column. Each column of trays **405** can include a top tray **565** positioned on the top of the column of trays **405**. The top trays **565** can include neutral connections C**4**, which may be 250 amp 12 mm diameter copper rods. Furthermore, the top trays **565** can include temperature sensors T**1** and pressure sensors P**1**. The temperature sensors T**1** can be RTDs or any other type of temperature sensors. The temperature sensors T**1** can have a body. The body can have a cylindrical or tubular shape. The body of the temperature sensors T**1** can extend through openings in a lateral side of the tray **565**. The openings can be circular or cylindrical shaped openings. The temperature sensors T**1** can extend between the front sides and the rear sides of the tray **565**. The temperature sensors T**1** can extend from the front sides towards the rear sides of the tray **565**. The temperature sensors T**1** can extend from the rear sides towards the front sides of the tray **565**. The temperature sensors T**1** can be electrically coupled or connected with a controller of the load bank module **105** in which the tray **565** is installed.

[0110] The temperature sensors T**1** can include at least one sensing element or component disposed in or along the body of the sensor **655**. The sensing element or component can measure temperature. For example, the sensing component can be a thermocouple, a resistance temperature detector (RTD), a thermally sensitive resistor (thermistor), a negative temperature coefficient thermistor, or any other type of temperature sensor. The sensing components can include a pressure sensor. The temperature sensors T**1** can include both a temperature sensing component and a pressure sensing component. The sensing components can be humidity, airflow, or any other kind of sensor that measures a characteristic or environmental condition of or within the tray **565**, a column of trays **405** which the tray **565** is positioned above, or the load bank module **105**. The sensing components of the temperature sensors T**1** can be electrically coupled with a controller of the load bank module **105**. The controller can measure the environmental characteristic or condition of a column of trays **405**. The temperature sensors T**1** can electrically communicate, provide, or transmit signals, values, or data indicating the environmental characteristic or condition to the controller.

[0111] Furthermore, the top trays **565** can include pressure sensors P**1**. The pressure sensors P**1** can be pressure sensors to detect a pressure differential between each top tray **565** and bottom tray **560**. For example, the pressure sensors of the top trays can measure a allow side, while the pressure sensors of the bottom trays can measure a high side. Furthermore, the top trays **565** can include an infrared probe. The pressure sensors P**1** can be electrically coupled with a controller of the load bank module **105**. The controller can measure the air pressure of a column of trays **405**. The temperature sensors P**1** can electrically communicate, provide, or transmit signals, values, or data indicating the environmental characteristic or condition to the controller.

[0112] Each column of trays **405** can include a bottom tray **560** positioned at the bottom of the column of trays **405**. The bottom trays **560** can include cable passe throughs C**1**, which can be 50 millimeter mica tubes. Furthermore, each bottom tray **560** can include a temperature sensor T**1** (similar or the same as the temperature sensor T**1** of the top tray **565**) and a pressure sensor P**1** (e.g., a high side pressure). Each bottom tray **560** can include tubes C**2** and C**3**, which can be mica tubes for 12 millimeter diameter dropper bars from the fuses **1705**. The bottom trays **560** can include access panels **570**.

[0113] Referring now to FIGS. **5**B-**5**C, an example bottom tray **560** is shown. FIG. **5**B illustrates a bottom tray **560** for a first load bank module **105**, e.g., the first load bank module **105 105** directly coupled to the transformer module **225**. FIG. **5**C illustrates a bottom tray **560** for a subsequent land bank, e.g., one or more load banks coupled with the first load bank or another load bank instead of being directly coupled with the transformer module **225**. The bottom tray **560** can include at least one jumper bus bar **580**. For example, a jumper bus bar **580** can connect connection C**3** to the bus bar **510** (which can be a particular phase bus bar). Furthermore, a bus bar **580** can connect connection C**2** to the bus bar **550** (which can also be a bus bar for the particular phase). A ring **585** (e.g., a copper distance ring) can connect different sections of the bus bar **510** together. The ring **585** can be coupled with the different sections of the bus bar **510** via washers, nuts, etc. In FIG. **5**C, an extra jumper **580** can be included to couple the bus bar **510** to the bus bar **550** though a ring, e.g., via a copper distance ring coupled to the bus bar **510** and bus bar **550** via at least one nut, bolt, or washer.

[0114] Referring now to FIGS. **6**-**7**, among others, a tray **405** including resistive components **535** is shown. The tray **405** can include multiple lateral walls, sides, or surfaces, e.g., front sides **605** and **610**, rear sides **615** and **620**, and lateral sides **625** and **630**. The sides of the tray **405** can form a prismatic shape, a rectangular solid shape, a cub shape, or any other type of shape. The tray **405** may not include any top or bottom side, to allow air to pass through the tray **405** to cool the resistive components **535**. In some implementations, the tray **405** can include top or bottom sides. The front sides **605** and **610** can be disposed opposite the rear sides **615** and **620**. The sides **605**, **610**, **615**, and **620** can be parallel with one another. The sides **630** can be disposed opposite sides **625**. The sides **625** and **630** can be parallel with each other. The sides **625** and **630** can be perpendicular with the sides **605**, **610**, **615**, and **620**.

[0115] The sides of the tray **405** can be formed from mica, such as dioctahedral mica, tetrahedral mica, trioctahedral mica, or interlayer-deficient mica. Any use of mica herein, in some implementations, can be dioctahedral mica, tetrahedral mica, trioctahedral mica, or interlayer-deficient mica. Because the sides of the tray **405** are formed of mica, and can remain stable at temperatures up to 500-900 degrees Celsius, the resistive cartridges **535** can dissipate heat without the tray **405** losing its structure or allowing a limited amount of bending or flexing. Because the tray **405** can be exposed to high temperatures without losing its form, the load bank **100** can dissipate high amounts of power (10 MWs, 20 MWs, etc.). The sides of the tray **405** can be formed from mica and can have a thickness of approximately 1 inch (25.4 millimeters). The thickness of the mica in the sides of the tray **405** can be 25-26 millimeters. The thickness of the mica in the sides of the tray **405** can be 24-27 millimeters. The thickness of the mica in the sides of the tray **405** can be 23-28 millimeters. The thickness of mica used in the sides can help sustain higher temperatures, and allow for the trays **405** to be rated up to 15,000 volts. By using mica of approximately 1 inch thickness, the tray **405** can reach higher temperatures, compared to other designs with may utilize metal sides of approximately ⅛th inch.

[0116] The tray **405** can include at least one support **645** and at least one support **650**. The supports **645** and **650** can be cylindrical shaped or tubular shaped components. The supports **645** and **650** can be formed from aluminum, steel, or mica. The supports **645** can couple with the front sides **605** or **610**. A first end of the supports **645** can couple with the front sides **605** or **610**. The supports **645** can couple with the back sides **620** or **615**. A second end of the supports **645**, opposite the first end, can couple with the back sides **620** or **615**. The supports **645** can extend between the front sides **605** and **610** and the back sides **620** or **615**. The supports **650** can couple with the lateral sides **625** or **630**. A first end of the supports **650** can couple with the lateral side **625**. A second end of the supports **650**, opposite the first end, can couple with the side **630**. The supports **650** can extend between the side **630** and **625**.

[0117] The front sides **605** and **610** can include openings **635** and **640**. The openings **635** and **640** can be circular or cylindrical shaped openings. The opening **635** and **640** can have circular shaped openings to allow a cylindrical shaped resistive component **535** to pass through the openings **635** and **640**. However, the openings **635** and **640** can be rectangular shaped, square shaped, or triangular shaped to allow a resistive component **535** with a rectangular, square, or triangular cross-section to pass through the openings **635** and **640**. The openings **635** and **640** can have diameters the same as, or greater than, the diameter of the resistive components **535**. The resistive components **535** can insert through the openings **635** and **640** to install or uninstall from the tray **405**. For example, the resistive components **535** can be inserted through the openings **635** and **640** from a first side of the sides **605** and **610** to a second side of the sides **605** and **610**, opposite the first side. The resistive components **535** can insert or be pushed from a first or outer side, through the openings **635** and **640**, into a body, cavity, space, or area of the trays **405**. Furthermore, the resistive components **535** can exit or be pulled from the trays **405** through the openings **635** and **640**. The trays **405** can provide continuous guided support for the resistive components **535** to be removed, e.g., pulled out, and installed, e.g., pushed in. The resistive components **535** can be partially or fully removed from a tray **405** and can be continuously supported as the components **535** are removed. The resistive components **535** can be removed or installed individually. For example, a service technician or other user can remove and replace a single resistive component **535**. The service technician can remove and replace one or multiple resistive components **535** from a tray **405** individually without uninstalling other resistive components **535** or uninstalling the tray **405** from the load bank module **105**.

[0118] Referring now to FIG. **8**, among others, is a tray **405** including bus bars **530** to form a circuit with resistive components **535**. At least a portion of the resistive components **535** can be disposed within the tray **405**, e.g., on an inner side of the side **605**. Furthermore, at least a portion of the resistive components **535** can be disposed on an outer side of the side **605**. The terminals **525** can be disposed or accessed on an outer side of the side **605**. For example, at least a portion of the terminal **525** can be disposed on an outer side of the side **605**. The bus bars **530** or the bus bars **510**, **515**, **520**, or **545** can couple the resistive components on the outer side of the side **605**. In this regard, the front outer side of the tray **405** can be a wiring board or area where a technician or assembly apparatus can wire the resistive components **535** together.

[0119] For example, the trays **405** can allow for configuration of wiring or connecting the resistor cartridges **535** installed in the trays **405**. For example, the trays **405** can be configurable for resistor cartridges **535** in series and/or parallel. For example, the trays **405** can be configurable to have resistor cartridges **535** in twenty four parallel paths or multiple parallel paths with some cartridges **535** in series. This configurability can allow for an improvement or optimization of watt per square inch power at the resistor coil surface, and a reduction in resistor coil surface operating temperature. The trays **405** can have configurability in order to operate at any one selected and configured operating voltage in the range of 480 to 15,000 volts, for example, 480 volts, 4160 volts, 10,000 volts, 11,000 volts, 13,800 volts, etc.

[0120] The front side **605** can include multiple openings **635**. The openings **635** can be organized in rows of openings. There can be one, two, three, four, or any number of rows of openings **635**. The rows of openings **635** can be offset from one another. Some rows of the openings **635** can be offset, while other row of openings **635** may not be offset. This can form a zig-zag pattern. For example, alternative rows of openings **635** can be offset, e.g., a first row of openings not offset, a second row of openings **635** offset, a third row of openings not offset, and a fourth row of openings offset. The offset rows can be offset a distance **815** towards an outer edge of the side **605**, for example, a left edge **805** or a right edge **810**. For example, a first row **820** of openings **635** can be shifted a distance **815** away from being centered with another second row **825** above or below the first row **820**, towards the edge **810**. The distance **815** can be 500-510 millimeters. The distance **815** can be 490-520 millimeters. The distance **815** can be less than 490 millimeters. The distance **815** can be greater than 520 millimeters.

[0121] A line tangent with openings **635** of an upper side of the row **820** and a line tangent with openings **635** of the bottom side of the row **825** can be separated by a distance **830**. The distance **830** can be approximately 412 millimeters (16.6 inches). The distances **830** can be 410-415 millimeters. The distance **830** can be 405-420 millimeters. The distance **830** can be less than 405 millimeters. The distance can be greater than 420 millimeters. A greatest or maximum distance between an outer side of an opening **635** of the first row **820** and an outer side of an opening **635** of a second row **825** (which both include resistive components **535** electrically coupled via a bus bar) can be a distance **835**. The distance **835** can be approximately 671 millimeters (26.41 inches). The distance **835** can be 665-675 millimeters. The distance **835** can be 660-680 millimeters. The distance **835** can be less than 660 millimeters. The distance **835** can be greater than 680 millimeters.

[0122] The tray **405** can include a ground connection **840**. The ground connection **840** can be electrically coupled with the earth. The ground connection **840** can provide a low resistance or impedance path to the earth.

[0123] Referring now to FIG. **9**, among others, a cross-section view of a tray **405** including resistive components **535** is shown. FIG. **9** illustrates an inner space of the tray **405**. The supports **650** can extend between the lateral sides **625** and **630**. First ends of the supports **650** can be coupled with the lateral side **630**. Second ends of the supports **650** can be coupled with the lateral side **625**. The supports **650** can be perpendicular to the lateral sides **625** and **630**. The supports **650** can be spaced from each other a distance **910** in a direction parallel with the surfaces of the lateral sides **630** and **625**. The distance **910** can be 200 millimeters. The distance **910** can be 198-202 millimeters. The distance **910** can be 196-204 millimeters. The distance **910** can be less than 196 millimeters. The distance **910** can be greater than 204 millimeters.

[0124] The bodies of the resistive components **535** can be spaced a distance **905**. For example, a line **915** tangent to the bottom sides of the cylindrical bodies of a row of resistive components and a line **920** tangent to upper sides of the cylindrical bodies of another row of resistive components **535** immediately below the first row, can be spaced the distance **905**. The distance **905** can be 92-94 millimeters. The distance **905** can be 91-95 millimeters. The distance **910** can be less than 91 millimeters. The distance **910** can be greater than 95 millimeters.

[0125] As shown in FIG. **9**, each tray **405** can include multiple resistive cartridges **535**. Each cartridge **535** can be removable from the load bank module **105** without removing the tray **405**. Furthermore, each cartridge **535** can be individually removable without needing to remove another cartridge **535**. As shown in FIG. **9**, the tray **405** can include 24 cartridges. However, the trays **405** can each include 23-25 cartridges, 22-26 cartridges, less than 22 cartridges, more than 26 cartridges, etc.

[0126] Referring now to FIG. **10**, among others, a side view of a tray **405** including rails **460** to install or uninstall from a load bank module **105**. The tray **405** can include one, two, three, four, or more rails **460** that extend from a front side **630** towards a rear side **625**. A view **1005** can illustrate a connection between one resistive component **535** and the side **630**. A view **1010** can illustrate a connection between the resistive component **535** and the side **625**. The tray **405** can have a length **1015**. The length **1015** can be 2.1-2.3 meters. The length **1015** can be 2.0-2.4 meters. The length **1015** can be less than 2.1 meters. The length **1015** can be greater than 2.4 meters.

[0127] Referring now to FIG. **11**, among others, the example view **1005** of a tray **405** where a resistive component **535** couples with a front lateral side of the tray **405**. The resistive component **535** can include a front portion, apparatus, device, or head **1105**. The head **1105** can be disposed in an opening **635** of the front portion **605**. The head **1105** can include a first portion **1110** and a second portion **1115**. The first portion **1110** of the head **1105** can extend into and through the opening **635** of the lateral side **605**. The first portion **1110** can have a cylindrical or tubular shape.

[0128] The head **1105** can include a second portion **1115**. The second portion **1115** can be disposed on an outer surface of the side **605**. The second portion **1115** can be a cylindrical or tubular shape. A diameter or radius of the portion **1115** can be greater than the diameter or radius of the opening **635**. In this regard, when the resistive component **535** is installed in the tray **405**, the portion **1115** can come into contact with an outer surface of the side **605** around the opening **635**, and stop or limit movement of the resistive component **535** as the resistive component **535** is inserted or installed in the tray **405**. The resistive component **535** can include at least one connector **1120**. The connectors **1120** can be screws, bolts, nails, snaps, or other components inserted through the portion **1115** of the head **1105** and into the lateral side **605**.

[0129] The resistive component **535** can include at least one connector **1150**. The connector **1150** can insert into or through a bus bar **530** into the terminal **525**. The terminal **525** can include a threaded opening or space that the connector **1150** can couple into via threads on the connector **1150**. The connector **1150** can be a nut, screw, bolt, nail, or any other connecting apparatus. The resistive component **535** can include a guide pin or guide rod or support member **1125**. The support member **1125** can be disposed within a housing, case, jacket, or insulator **1135**. The insulator **1135** and the support member **1125** can insert into a cavity **1143** of the second portion **1115**. The cavity **1143** can be a cylindrical shaped cavity. A distance **1130** can extend from an inner surface or end **1145** of the cavity **1143** to a body or resistive coils of the resistive component. The distance **1130** can be 45-55 millimeters. The distance **1130** can be 40-60 millimeters. The distance **1130** can be less than 40 millimeters. The distance **1130** can be greater than 60 millimeters.

[0130] Referring now to FIG. **12**, among others, an example view **1010** of a tray **405** where a resistive component **535** couples with a rear lateral side **625** of the tray **405**. The resistive component **535** can include a rear end **1205**. The rear end **1205** can be a washer, cap, apparatus, or device. The rear end **1205** can be formed from or include mica. The rear end **1205** can include a first portion **1210** and a second portion **1215**. The first portion **1210** and the second portion **1215** can be integrally formed or can be separately joined or coupled components. The portion **1210** and the second portion **1215** can be cylindrical shaped components. The first portion **1205** can include circular openings for coils **1220** of wire to pass through. The second portion **1215** can extend from the first portion **1205**, through an opening in the side **620**, and towards or to the side **625**. The support member **1125** can extend through the first portion **1205** and the second portion **1225** through a channel, opening, or space of the rear end **1205**. The support member **1125** can extend to, into, or through a connector **1133**. The connector **1133** can be a bolt, screw, threaded receiver, or magnetic coupling. A component **1140** can be inserted into or through the side **625**. The component **1140** can be a threaded component, bolt, or screw that is part of or couples to the connector **1133**. The connector **1133** and the component **1140** can couple the resistive component **535** with the side **625**.

[0131] Referring now to FIG. **13**, among others, a rear view of a tray **405** to install with a load bank module **105** is shown. The tray **405** can include openings **1305** on the rear side **625** which couple with the resistive components **535**. The connectors, such as nuts, bolts, screws, snaps, or other connectors, couple the resistive components **535** with the side **625**. The side **625** can have a width **1315**. The side **625** can have a height **1310**. The width **1315** and the height **1310** can be the width **1315** and height **1310** of the tray **405**, and not just the side **625**. The width **1315** can be 540-560 millimeters. The width **1315** can be 530-570 millimeters. The width **1315** an be less than 530 millimeters. The width **1315** can be greater than 570 millimeters.

[0132] Referring now to FIGS. **14-15**D, among others, a resistive component **535** including turns **1435** of wire **1430**. The resistive component **535** can include terminals **525**. The terminals **525** can be electrically coupled via bus bars with other resistive components **535**, with a phase of the power source, or with a neutral of the power source. The terminals **525** can be electrically coupled or connected with wire **1430**. The wire **1430** can be shaped in a coil, spring, or spiral pattern (e.g., as shown in FIG. **15**B). Each ring of the spiral of the wire **1430** can be separated a distance **1505** from another ring of the coil of the wire **1430**. For example, the distance **1505** can be between outer diameters of each ring of the spiral, and can be approximately 1.5 millimeters. The wire **1430** can be or include a Kanthal, Nikrothal, or other type of material. The wire **1430** can have a diameter of 0.8-0.9 millimeters. The wire **1430** can have a diameter of 0.75-0.95 millimeters. The wire **1430** can have a diameter less than 0.75 millimeters. The wire **1430** can have a diameter greater than 0.95 millimeters. The coiled wire **1430** can bend upwards, downwards, or sideways to allow for expansion due to increased temperature. The resistive component **535** may not include conventional springs to allow for temperature based expansion, and therefore can avoid having a short electrical path to ground for high voltage to jump to from one coil to another.

[0133] The resistive component **535** can have a first surface, end, or side **1405** and a second surface, end or side **1410**. The first side **1405** and the second side **1410** can be opposite one another and located at either end of a length of the resistive component **535**. The first side **1405** can be a front side defined by the head **1105**. The second side **1410** can be a rear side defined by the end **1410**.

[0134] The wire **1430** can extend back and forth between the first side **1405** of the resistive component **535** and the second side **1410** of the resistive component **535**. The wire **1430** can extend from the first side **1405** to the second side **1410** or from the second side **1410** to the first side **1405** in a direction parallel with the longitudinal axis **1415** of the resistive component **535**. The wire **1430** can extend back and forth between the first side **1405** and the second side **1410** in a spiral pattern, corkscrew pattern, coil pattern, or spring pattern (e.g., as shown in FIG. **15**B). The wire **1430** can extend from the first side **1405**, to the second side **1410**, and back to the first side **1405** to form turns **1435** of the resistive component **535**. The wire **1430** can extend back and forth between the first side **1405** and the second side **1410** to form multiple turns **1435**. Each turn **1435** can be a length of the wire **1430** extending from one of side to the other (e.g., from first side **1405** to second side **1410**, or from second side **1410** to first side **1405**). The resistive component **535** can include 10-13 turns **1435**. The resistive component **535** can include 9-14 turns **1435**. The resistive component **535** can include less than 9 turns **1435**. The resistive component **535** can include more than 14 turns **1435**. The resistive component **535** can include 12 turns **435**.

[0135] The resistive component **535** can include at least one disc **1425**. The disc **1425** can be a washer or spacer. The disc **1425** can be formed from or include mica. The disc **1425** can be formed from electrically non-conductive material such as mica, ceramic, etc. Because the disc **1425** is non-conductive, the disc **1425** can provide electrical isolation and can be used at high temperature operation (600 to 1000 deg C.). The disc **1425** can have a cylindrical or disc shape. The discs **1425** can be disposed along a longitudinal axis **1415**. The discs **1425** can be disposed between the first side **1405** and the second side **1410**. The discs **1425** can be spaced from each other a distance **1440**. The distance **1440** can be 60-65 millimeters. The distance **1440** can be 55-70 millimeters. The distance **1440** can be less than 55 millimeters. The distance **1440** can be greater than 70 millimeters. The discs **1425** can include openings, holes, or spaces for the wire **1430** to pass through. The openings can be circular, oval, or stadium shaped. For example, the discs **1425** can include openings for each turn **1435**, a first opening of the wire **1430** to extend through where the wire **1430** extends from the first side **1405** to the second side **1410**, and a second opening for the wire **1430** to extend through where the wire **1430** extends from the second side **1410** to the first side **1405**. The wire **1430** can extend back and forth between the first side **1405** and the second side **1410** through the openings in the discs **1425**. The wire **1430** can extend in a spiral pattern between the first side **1405** and the second side **1410**. FIG. **15**C illustrates the resistive component **535** along the cross-section P-P shown in FIG. **15**A. In FIG. **15**C, holes **1510** are shown in a disc **1425** (although each disc **1425** can have similar holes). The holes **1510** are separated a distance **1515**. The distance **1515** can be approximately 9 millimeters.

[0136] The resistive component **535** can include the support member **1125**. The support member **1125** can have a cylindrical, tubular, or rod shape. The support member **1125** can be a guiding inner rod for support and to assist with installation or removal of the resistive component **535** from the tray **405**.

[0137] The support member **1125** can extend between the first side **1405** and the second side **1410**. The support member **1125** can extend along the longitudinal axis **1415** of the resistive component **535**. The support member **1125** can be centered on the longitudinal axis **1415**. A length of the support member **1125** can be parallel with the longitudinal axis **1415**. The support member **1125** can extend through openings in the discs **1425**. The discs **1425** can be positioned such that circular surfaces of the discs **1425** are perpendicular with the longitudinal axis **1415**. The discs **1425** can be centered on the longitudinal axis **1415**, and an opening of the discs **1425** that the support member **1125** of each disc **1425** that the support member **1125** extends through can be centered on the longitudinal axis **1415**. The centered openings of the discs **1425** can be circular in shape, and have a radius or diameter greater than a radius or diameter of a cross-section of the support member **1125**.

[0138] The resistive component **535** can have a length **1475**. The length **1475** can be a distance between the first side **1405** and the second side **1410**. The length **1475** can be a distance from a surface **1450** of the second portion **1115** of the head **1105** to and end of the rear end **1205**. The length **1475** can be 1240-1250 millimeters. The length **1475** can be 1230-1260 millimeters. The length **1475** can be less than 1230 millimeters. The length **1475** can be greater than 1260 millimeters. A distance **1455** between the surface **1450** of the second portion **1115** of the head **1105** and a first disc **1425** (or a disc **1425** closest to the first side **1405**) can be 65-70 millimeters. The distance **1455** can be 60-75 millimeters. The distance **1455** can be less than 60 millimeters. The distance **1455** can be greater than 75 millimeters. A distance **1470** between an end of the terminal **525** and the surface **1465** of the second portion **1115** of the head **1105** can be 14-15 millimeters. The distance **1470** can be 13-16 millimeters. The distance **1470** can be less than 13 millimeters. The distance **1470** can be greater than 16 millimeters.

[0139] The disc **1425** can have a thickness **1460**. The thickness **1460** can be 6-7 millimeters. The thickness **1460** can be 5-8 millimeters. The thickness **1460** can be less than 5 millimeters. The thickness **1460** can be greater than 7 millimeter. A distance **1445** between a surface **1465** and the surface **1450** (e.g., a thickness of the second portion **1115**) can be 6-7 millimeters. The distance **1445** can be 5.5-7.5 millimeters. The distance **1445** can be less than 5.5 millimeters. The distance **1445** can be greater than 7.5 millimeters.

[0140] In FIG. **15**D, the resistive component **535** is an example cross-sectional view of the resistive component along a length of the resistive component. The support member **1125** can be threaded, or have at least one threaded end. The support member **1125** can extend from a first threaded end on a front side **1405** through the resistive component **535** to a second threaded end on a rear side **1410** of the resistive component **535**. At the front side **1405**, an end of the support member **1125** can extend through a surface in the head **1105**, and can include an exposed portion that at least one washer **1520**, lock nut **1525**, or nut **1530** (e.g., dome nut) can be coupled. At the rear side **1410**, an end of the support member **1125** can be threaded, and screw into or insert into a component **1535**. The component **1535** can be embedded within the side **625**. The component **1535** can be a wood insert nut. A washer **1540** can be disposed about the support member **1125** on an outer side of the side **625**, and a nut **1545**, such as a lock nut, can be coupled to the end of the support member **1125**.

[0141] Referring now to FIGS. **16**A-B, among others, a fan apparatus **1605** is shown. The fan apparatus **1605** can include at least one housing **1610**. The housing **1610** can be formed from or include steel, aluminum, titanium, etc. The housing **1610** can be a bottom portion of a housing **115** of a load bank module **105**. The housing **1610** can be disposed between a surface, such as the bed of a truck, the ground, pavement, concrete, and the housing **115** of the load bank module **105**. The fan apparatus **1605** can be disposed between a bottom side, bottom surface, or bottom panel of a load bank module **105** and the trays **405** and resistive components **535** of the load bank module **105**. Each load bank module **105**, or at least one load bank module **105**, can include a fan apparatus **1605**. The fan apparatus **1605** can be disposed below the trays **405**, the bottom trays **560**, the resistive components **535**, etc.

[0142] The fan apparatus **1605** can include an opening on a first side of the housing **1610** to draw air inwards along a first direction **1615**. The fan apparatus **1605** can include at least one fan or blower **1620**. The blowers **1620** can run to draw air along the direction **1615** into the housing **1610** through the opening in the side of the housing **1610**. The fan apparatus **1605** can include at least one component, directional component, or air guide vane **1625**. The air guide vane **1625** can be a wall, surface, or panel that directs air. The guide vanes **1625** can direct horizontal air flow to a 90° bend for vertical air flow, directed upward to the resistor trays **405**. Two opposing horizontal air flows can be drawn in by the opposing blowers **1620**, and directed upward vertically by the respective air guide vanes **1625** combine the air drawn in by the blowers **1620** into one air flow. This configuration can provide a more uniform vertical air flow to resistor coil **535** in trays **405** with reduce a pressure drop. Each of fan outlet air flows is guided through the guide vanes **1625** for a minimum or lower pressure drop and to reduce turbulence.

[0143] The air guide vane **1625** can direct air pulled in by the blowers **1620** upwards, along a second direction **1630**. The air guide vane **1625** can direct air from a first direction **1615** ninety degrees to a second direction **1630**. The directions **1615** and **1630** can be substantially perpendicular with each other. The directions **1615** and **1630** can form an angle between 85-95 degrees. The directions **1615** and **1630** can form an angle between 80-100 degrees. The directions **1615** and **1630** can form an angle less than 80 degrees. The directions **1615** and **1630** can form an angle greater than 100 degrees. The fan apparatus **1605** can include blowers **1620** on opposing sides facing each other (e.g., as shown in the cross-sectional view of FIG. **16**B). The blowers **1620** can draw in air from opposing sides of the fan apparatus, and the air guide vanes **1625** can direct the air upwards towards the resistive components **535**. A first air guide vane **1625** can redirect air drawn in by blowers **1620** on a first side of the fan apparatus **1605**, while a second air guide vane **1625** can redirect air drawn in by blowers **1620** on a second opposite side of the fan apparatus **1605**. The fan apparatus **1605** can provide air to cool resistive components **535** in one airflow duct, e.g., the fan apparatus **1605** can cool resistive components dissipating 4,000 kW in one airflow duct.

[0144] The blowers **1620** can pull the air from outside the load bank module **105** into the load bank module **105**. The blowers **1620** can pull the air in the direction **1615** and through at least one screen **1635** of the fan apparatus **1605**. The screen **1635** can be a mesh or a filter that prevents objects or particles from entering the load bank module **105**. The air guide vane **1625** can direct the airflow away from a bottom of the load bank module **105** upwards towards the trays **405** or the resistive components **535**. The airflow can pass over or through the trays **405** and over or through the resistive components **535**. The airflow can cool the trays **405**, the resistive components **535**, or other components of the load bank module **105**. The airflow can exit the load bank module **105** out the openings **125**.

[0145] Referring now to FIGS. **16**C-**16**F, among others, the air guide vane **1625** is shown. The air guide vane **1625** can include at least one vertical portion **1640**. The air guide vane **1625** can include a vertical portion **1640** on opposing sides of the air guide vane **1625** which can support or couple the air guide vane **1625** to a bottom surface or side surface of the fan apparatus **1605**. Each of the vertical portions **1640** can support an angled portion **1645**. Each angled portion **1645** can be positioned parallel to one another. The air guide vane **1625** can include individual vanes **1650**. The vanes **1650** can extend between the angled portions **1645**. FIG. **16**G depicts a cross-sectional view of the air guide vane **1625** along cross-section F-F of FIG. **16**E. The vanes **1650** can be curved or have a concave inner surface to redirect air from an oncoming airflow from a direction **1615** to direction upwards **1630**.

[0146] Referring now to FIG. **17**A, among others, a high voltage side of load bank modules **105** including fuses **1705** is shown. The fuses **1705** can be devices that disconnect trays **405** or resistive components **535** from the power source. The fuses **1705** can disconnect or break a circuit or electrical connection between a power source and the trays **405** or resistive components **535** responsive to a level of current exceeding a threshold. Each load bank module **105** can include at least one fuse **1705**. Each load bank module **105** can include at least three fuses **1705**. A first end or terminal of the fuses **1705** can be coupled with a bus bar **420** that electrically couples the fuse **1705** with a set or group of trays **405**. A second end or terminal of the fuses **1705** can be coupled, either directly or indirectly, with the power source, or with a particular terminal of the power source for a particular phase.

[0147] Each load bank module **105** can include a fuse **1705** to switch a different phase of the power source. For example, the load bank module **105** can include a first fuse **1705** in an electrical path between a first set of trays **405** and a first phase of the power source. The first fuse **1705** can disconnect the first set of trays **405** from the first phase of the power source responsive to the current of the first phase exceeding a threshold of the first fuse **1705**. The load bank module **105** can include a second fuse **1705** in an electrical path between a second set of trays **405** and a second phase of the power source. The second fuse **1705** can disconnect the second set of trays **405** from the second phase of the power source responsive to the current of the second phase exceeding a threshold of the second fuse **1705**. The load bank module **105** can include a third fuse **1705** in an electrical path between a third set of trays **405** and a third phase of the power source. The third fuse **1705** can disconnect the third set of trays **405** from the third phase of the power source responsive to the current of the third phase exceeding a threshold of the third fuse **1705**.

[0148] Referring now to FIG. **17**B, among others, an example view of a low voltage side of load bank modules **105** including trays **405** is shown. Each of trays **405** are exposed on a front side. Each load bank module **105** can include at least one stack of trays **405**. Each stack of trays **405** can provide resistive components **535** for dissipating power of one phase of an AC source. For example, each load bank module **105** can include three stacks of trays **405**.

[0149] Referring now to FIGS. **18**-**19**, among others, an example circuit **1800** of load bank modules **105** coupled with a power source **1805** is shown. The power source **1805** can be a generator system, a battery system, an uninterruptible power supply, a photovoltaic system, a turbine system, or any other power generating system, apparatus, or piece of equipment. The power source **1805** can provide 480 to 15,000 volts alternating current (AC) power. For example, the power source **1805** can provide 13,800 volts AC) power. The power source **1805** can provide 13,700-13,900 volts of AC power. The power source **1805** can provide 13,110-14,490 volt of AC power. The AC power can be 50 or 60 hertz power. The phases of the power source **1805** can be sinusoidal, and approximately 120 degrees out of phase with each other. The power source **1805** can include a ground **1845**, that can be coupled with a ground bus bar **1850** of the load bank module **105**.

[0150] The transformer module **225** can be electrically coupled via one, two, three, or multiple cables with the power source **1805**. The transformer module **225** can include a transformer **1810** to step down the voltage from the power source **1805**. The transformer **1810** can have a transformation ratio to step the voltage down to approximately 120 volts AC. The power meter **1815** can be a microcontroller, circuit board, or computing system that can measure the voltage of the power source **1805** via the voltage provided by the transformer **1810**. The transformer module **225** can include a current transformer (CT) **1820**. A coil of the CT **1820** can be disposed or wound about a bus bar **1825** coupled with the power source **1805**. Current passing through the bus bar **1825** can induce a current in the coil of the CT **1820**, which can be sensed or measured by the power meter **1815**.

[0151] The power meter **1815** can measure voltage and current from the power source **1805**. The power meter **1815** can use the voltage and current to determine power. The power meter **1815** can measure power from 0.5 to 35 MW. The power meter **1815** can measure power between 1-25 MW. The power meter **1815** can measure power less than 1 MW. The power meter **1815** can measure power greater than 25 MW.

[0152] The bus bar **1825** can be coupled with a first load bank module **105** via a flexible bus bar **1830**. For example, the three phases of the power source **1805** can be coupled with the first load bank **105** via a first flexible bus bar **1830** while a second load bank module **105** can be electrically coupled with the first load bank module **105** and the power source **1805** via a second flexible bus bar **1830**. The load bank modules **105** can be electrically coupled in parallel with one another and the power source **1805**. The load bank modules **105** can be rated for voltages 480 to 15,000 volts. In this regard, the load bank modules **105** can couple directly with the power source **1805**, instead of coupling to the power source **1805** through a stepdown transformer.

[0153] The load bank modules can include fuses **1705** between steps, disconnects, contactors, or switches **1835** and the three phases of the power source **1805**. The load bank modules **105** can include a circuit or current path from a first phase of the power source **1805**, through a first fuse **1705**, through a first contactor **1835**, and through a first set of trays **405** and resistive components **535**. The load bank modules **105** can include a similar path for each phase. For example, the load bank modules **105** can include a circuit or current path from a second phase of the power source **1805**, through a second fuse **1705**, through a second contactor **1835**, and through a second set of trays **405** and resistive components **535**. Furthermore, the load bank modules **105** can include a circuit or current path from a third phase of the power source **1805**, through a third fuse **1705**, through a third contactor **1835**, and through a third set of trays **405** and resistive components **535**. The load bank modules **105** can include minimum steps **1835** of 1,000 KW to 1,300 KW. The load bank modules **105** can include maximum steps of 4,000 kW to 5,600 KW. The steps **1835** can be configurable, e.g., configured to 4,000 kW, 3,300 kW, 2,667 kW, 1,333 kW, 700 kW.

[0154] The first set of steps **1835** can electrically couple the phases of the power source **1805** with all of the trays **405** of the load bank module **105**. The current from the first set of steps **1835** to the trays **405** can be approximately 55 amperes, e.g., 50-60 amperes. The current from the first set of steps **1835** to the trays **405** can be 45-65 amperes. The current from the first set of steps **1835** can be less than 45 amperes. The current from the first set of steps **1835** can be greater than 65 amperes.

[0155] The second set of steps **1835** can electrically couple the phases of the power source **1805** with a portion of the trays **405** of the load bank module **105**. For example, each phase from the second set of steps **1835** can be electrically coupled with two trays **405**. The current from the second set of steps **1835** to the trays **405** can be approximately 111 amperes, e.g., 100-115 amperes. The current from the second set of steps **1835** to the trays **405** can be 95-120 amperes. The current from the first set of steps **1835** can be less than 95 amperes. The current from the second set of steps **1835** can be greater than 120 amperes.

[0156] The transformer module **225** can be electrically coupled with the three phases of the power source **1805**. The transformer module **225** can be electrically coupled with the three phases of the power source **1805** through electrical connections via bus bars or flexible bus bars **1830** of the load bank modules **105**. The transformer module **225** can include a manual disconnect or switch **1850**. The transformer module **225** can include at least one transformer **1840**. The transformer **1840** can be a delta or star configured transformer. The transformer **1840** can transform a voltage of the phases of the power source **1805** to a voltage for components of the load bank **100** to operate on. For example, the transformer **1840** can convert a voltage from 13,800 volts AC to 480 volts AC. The transformed voltage can be used to operate various components of the load bank module **105**, such as the blowers **1620**, or any other electrically actuated component.

[0157] Referring now to FIGS. **20**A-**20**B, among others, an example circuit **2000** of controllers of load bank modules **105** that control the load bank modules **105** is shown. The transformer module **225** can include at least one controller **2005**. The controller **2005** can be electrically coupled with the network hub **2010** or can include the network hub **2010**. The network hub **2010** can be electrically coupled with the controller **2005** of the transformer module **225** or the controllers **2015** of the load bank module **105**. The controller **2005** and the controllers **2015** can be programmable logic controllers, computing systems, data processing systems, microcontrollers, or any other general purpose or specific purpose processing system. The controller **2005** can transmit control commands or control decisions to the controllers **2015**. The controllers **2015** can transmit data, measurements, or other information to the controller **2005**, and the controller **2005** can receive the data from the controllers **2015**. The controller **2005** can cause, via communication through the network hub **2010**, data to be displayed on the user interface **2020** (shown in FIG. **20**B).

[0158] The transformer module **225** can include a user interface **2020**. The user interface **2020** can be or include a light emitting diode (LED) display, a liquid crystal display (LCD), or an organic light emitting display (OLED). The user interface **2020** can be electrically coupled with the controller **2005** via the network hub **2010**. The controller **2005** can cause the user interface **2020** to display information, measurements, or other data that the controller **2005** generates, calculates, or collects. For example, the controller **2005** can receive measurements from the power meter **1815** and cause the user interface **2020** to display the measurements.

[0159] The controller **2005** can include digital inputs. The digital inputs can include an emergency stop input. For example, responsive to receiving an indication to stop the load bank module **105** from a switch, lever, or other device, the controller **2005** can operate one or more switches or contactors to disconnect the load bank module **105** from the power source **1805**. The controller **2005** can include inputs to receive signals from a load step, a blower motor, a model selection input device. The controller **2005** can include an input from a door switch that indicates whether the door of the transformer module **225** is open or closed. The controller **2005** can include manual switch inputs for load steps. The controller **2005** can include digital outputs. The digital outputs can be air fail outputs, overload outputs, overtemperature and emergency stop outputs, and door panel lock outputs to lock a door of the load bank module **105**. The analog inputs of the controller **2005** can be a temperature measurement input.

[0160] The controllers **2015** can include digital outputs, digital inputs, and analog inputs for each respective load bank module **105**. For example, the controllers **2015** can include a vacuum contactor output that the controller **2015** can turn on or off. The controllers **2015** can include fan motor outputs to turn on or off motors of the blowers **1620**. The controllers **2015** can include a panel door lock output to lock or unlock the doors of the load bank modules **105**. The controllers **2015** can include a heater output that the controller **2015** can turn on, or turn off, or adjust the level of heating provided by a heater of the load bank module **105**. The controllers **2015** can include digital inputs that indicate whether a door is open or closed, a door limit switch, an air pressure meter. The controllers **2015** can include temperature input for each tray **405** of the load bank module **105**, temperature differential, an electric panel temperature inputs. The transformer module **225** can include at least one controller **2015**. The controller **2015** can include a temperature switch digital input. The controller **2015** can include digital outputs to operate a heater. The controller **2015** can include digital outputs to operate motors of the blowers **1620** of the load bank modules **105**.

[0161] In some implementations, the controller **2015** can provide two channel power measurements of voltages from 80 to 600 volts AC and 8 to 15,000 volts DC. With an external power transformer, the controller **2015** can provide measurements from 600 to 15,000 volts AC. With an external current transformer, the controller **2015** can provide current measurements of 1 to 5 amperes. The controllers **2015** can measure AC signals of one, two, or three phases, measure power factor, or measure frequency of an AC signal (e.g., a 50 hertz AC signal, a 60 hertz AC signal, a 400 hertz AC signal). The controllers **2015** can provide control power and fan motor power monitoring. The controllers **2015** can measure low voltages and/or currents. The system can provide fan motor protection for unbalanced phases, loss of phases, overload current based on the frequency (e.g., 50 or 60 hertz) and motor parameters. The motor parameters can be self-tuning. The controller **2015** can find or record in an auto set up mode.

[0162] Referring now to FIG. **21**, among others, an example method **2100** of providing a load bank **100** is shown. The method **2100** can be performed by a manufacturing system, manufacturing apparatus, a manufacturing individual, a technician, an installation service member, a robotic assembly system, or any other system, apparatus, or component. The method **2100** can include an ACT **2105** of providing resistors. The method **2100** can include an ACT **2110** of disposing resistors in trays. The method **2100** can include an ACT **2115** installing trays in modules. The method **2100** can include an ACT **2120** of coupling modules.

[0163] At ACT **2105**, the method **2100** can include providing resistors **535**. For example, the method **2100** can include manufacturing, assembling, or obtaining resistors **535** for installation with trays **405**. The method **2100** can include providing a support member **1125** for the resistive component **535**. The support member **1125** can have a cylindrical shape. The method **2100** can include providing a head **1105**, which can define or be positioned on a first side **1405** of the cylindrical resistive component **535**. The method **2100** can include coupling an end of the support member **1125** with the head **1105**. For example, the support member **1125** can be inserted through an opening in the head **1105**. The method **2100** can include providing the discs **1425**, and machining, forming, or drilling holes in the discs **1425**. The method **2100** can include disposing discs **1425** on the support member **1125**. The discs **1425** can be spaced from a first end **1405** of the resistive component **535** to a second end **1410**. The ACT **2105** can include providing windings or turns **1435**. For example, the method **2100** can include coiling the wire **1430**. The method **2100** can include passing the wire through the openings in the discs **1425** from the first end **1405** to the second end **1410** and from the second end **1410** to the first end **1405**. The method **2100** can include coupling a first end of the wire **1430** with a first terminal **525** of the resistive component **535**. The method **2100** can include coupling a second end of the wire **1430** with a second terminal **525**.

[0164] At ACT **2110**, the method **2100** can include disposing resistors **535** in trays **405**. The method **2100** can include disposing the resistors **535** in the trays **405** to dissipate power received from the power source **1805**. The resistors **535** can be formed to be removably coupled with the trays **400**. The method **2100** can include drilling or forming holes or openings **635** in an opening in a side **605** of the tray **405**. The method **2100** can include inserting the resistive components **535** through the openings **635** into the trays **405**. The method **2100** can include coupling the head **1105** with the side **605**. For example, a surface of a second portion **1115** of the head **1105** can couple with a surface of the side **605**. Furthermore, connectors **1120** can couple the head **1105** with the side **605**. The method **2100** can include coupling the rear end **1205** with the side **625** via connectors **1130** and **1140**.

[0165] At ACT **2115**, the method **2100** can include installing the trays **405** in the load bank modules **105**. For example, the method **2100** can include disposing the trays **405** in a load bank module **105** to removably couple with the load bank module **105**. The method **2100** can include disposing, coupling, or fixing at least one first rail **460** to an outer surface of the side **625** of the tray **405**. The method **2100** can include disposing at least one second rail on an inner surface of the side **415**. The method **2100** can include coupling the at least one first rail **460** with the at least one second rail of the load bank module **105**. The method **2100** can include installing or uninstalling, via the first rail **460** and the second rail, the tray **405** with the load bank module **105**. The method **2100** can include stacking the trays **405** in columns within the housing **410** of the load bank module **105**. For example, the housing **410** can have sets of rails to allow the trays **405** to install in the load bank module **105** in columns and rows of trays **405**. The method **2100** can include coupling a first set or column of trays **405** with a first phase of the power source **1805**. The method **2100** can include coupling a second set or column of trays **405** with a second phase of the power source **1805**. The method **2100** can include coupling a first set or column of trays **405** with a third phase of the power source **1805**. For example, via bus bars **510**, bus bars **550**, and bus bars **555**, a first set of trays **405** can be coupled with a first phase, a second set of trays **405** can be coupled with a second phase, and a third set of trays **405** can be coupled with a third phase.

[0166] The method **2100** can include coupling the load bank modules **105**. For example, the method **2100** can include coupling the load bank modules **105** together. The method **2100** can include coupling at least one load bank module **105** with at least one other load bank module **105** to dissipate the power received from the power source **1805**. The method **2100** can include coupling the load bank modules **105** in parallel with the power source **1805**. A first load bank module **105** can be electrically coupled with the power source **1805** through an transformer module **225** of the load bank **100**. A second load bank module **105** can be electrically coupled with the power source **1805** through electrical connections of the first load bank module **105**. The method **2100** can include electrically connecting the load bank modules **105** with one another via flexible bus bars **1830**, rigid bus bars, or cables.

[0167] Referring now to FIG. **22**, among others, an example computing architecture of a controller **2005** is shown. The architecture described in FIG. **22** can be used to implement the controller **2005**, the network hub **2010**, the power meter **1815**, the user interface **2020**, the communication monitor **2025**, or the controller **2015**. The controller **2005** can include at least one bus **2225** or other communication component for communicating information and at least one processor **2230** or processing circuit coupled to the bus **2225** for processing information. The controller **2005** can include one or more processors **2230** or processing circuits coupled to the bus **2225** for processing information. The controller **2005** can include at least one main memory **2210**, such as a random access memory (RAM) or other dynamic storage device, coupled to the bus **2225** for storing information, and instructions to be executed by the processor **2230**. The main memory **2210** can be used for storing information during execution of instructions by the processor **2230**. The controller **2005** can further include at least one read only memory (ROM) **2215** or other static storage device coupled to the bus **2225** for storing static information and instructions for the processor **2230**. A storage device **2220**, such as a solid state device, magnetic disk or optical disk, can be coupled to the bus **2225** to persistently store information and instructions.

[0168] The controller **2005** can be coupled via the bus **2225** to a display **2200**, such as a liquid crystal display, or active matrix display. The display **2200** can display information to a user. An input device **2205**, such as a keyboard or voice interface can be coupled to the bus **2225** for communicating information and commands to the processor **2230**. The input device **2205** can include a touch screen of the display **2200**. The input device **2205** can include a cursor control, such as a mouse, a trackball, or cursor direction keys, for communicating direction information and command selections to the processor **2230** and for controlling cursor movement on the display **2200**.

[0169] The processes, systems and methods described herein can be implemented by the controller **2005** in response to the processor **2230** executing an arrangement of instructions contained in main memory **2210**. Such instructions can be read into main memory **2210** from another computer-readable medium, such as the storage device **2220**. Execution of the arrangement of instructions contained in main memory **2210** causes the controller **2005** to perform the illustrative processes described herein. One or more processors in a multi-processing arrangement can be employed to execute the instructions contained in main memory **2210**. Hard-wired circuitry can be used in place of or in combination with software instructions together with the systems and methods described herein. Systems and methods described herein are not limited to any specific combination of hardware circuitry and software.

[0170] Although an example computing system has been described in FIG. **22**, the subject matter including the operations described in this specification can be implemented in other types of digital electronic circuitry, or in computer software, firmware, or hardware, including the structures disclosed in this specification and their structural equivalents, or in combinations of one or more of them.

[0171] Some of the description herein emphasizes the structural independence of the aspects of the system components or groupings of operations and responsibilities of these system components. Other groupings that execute similar overall operations are within the scope of the present application. Modules can be implemented in hardware or as computer instructions on a non-transient computer readable storage medium, and modules can be distributed across various hardware or computer based components.

[0172] The systems described above can provide multiple ones of any or each of those components and these components can be provided on either a standalone system or on multiple instantiations in a distributed system. In addition, the systems and methods described above can be provided as one or more computer-readable programs or executable instructions embodied on or in one or more articles of manufacture. The article of manufacture can be cloud storage, a hard disk, a CD-ROM, a flash memory card, a PROM, a RAM, a ROM, or a magnetic tape. In general, the computer-readable programs can be implemented in any programming language, such as LISP, PERL, C, C++, C#, PROLOG, Python, LAD, FBD, ST, IL, SFC or in any byte code language such as JAVA. The software programs or executable instructions can be stored on or in one or more articles of manufacture as object code.

[0173] Example and non-limiting module implementation elements include sensors providing any value determined herein, sensors providing any value that is a precursor to a value determined herein, datalink or network hardware including communication chips, oscillating crystals, communication links, cables, twisted pair wiring, coaxial wiring, shielded wiring, transmitters, receivers, or transceivers, logic circuits, hard-wired logic circuits, reconfigurable logic circuits in a particular non-transient state configured according to the module specification, any actuator including at least an electrical, hydraulic, or pneumatic actuator, a solenoid, an op-amp, analog control elements (springs, filters, integrators, adders, dividers, gain elements), or digital control elements.

[0174] The subject matter and the operations described in this specification can be implemented in digital electronic circuitry, or in computer software, firmware, or hardware, including the structures disclosed in this specification and their structural equivalents, or in combinations of one or more of them. The subject matter described in this specification can be implemented as one or more computer programs, e.g., one or more circuits of computer program instructions, encoded on one or more computer storage media for execution by, or to control the operation of, data processing apparatuses. Alternatively or in addition, the program instructions can be encoded on an artificially generated propagated signal, e.g., a machine-generated electrical, optical, or electromagnetic signal that is generated to encode information for transmission to suitable receiver apparatus for execution by a data processing apparatus. A computer storage medium can be, or be included in, a computer-readable storage device, a computer-readable storage substrate, a random or serial access memory array or device, or a combination of one or more of them. While a computer storage medium is not a propagated signal, a computer storage medium can be a source or destination of computer program instructions encoded in an artificially generated propagated signal. The computer storage medium can also be, or be included in, one or more separate components or media (e.g., multiple CDs, disks, or other storage devices including cloud storage). The operations described in this specification can be implemented as operations performed by a data processing apparatus on data stored on one or more computer-readable storage devices or received from other sources.

[0175] The terms "computing device", "component" or "data processing apparatus" or the like encompass various apparatuses, devices, and machines for processing data, including by way of example a programmable processor, a computer, a system on a chip, or multiple ones, or combinations of the foregoing. The apparatus can include special purpose logic circuitry, e.g., an FPGA (field programmable gate array) or an ASIC (application specific integrated circuit). The apparatus can also include, in addition to hardware, code that creates an execution environment for the computer program in question, e.g., code that constitutes processor firmware, a protocol stack, a database management system, an operating system, a cross-platform runtime environment, a virtual machine, or a combination of one or more of them. The apparatus and execution environment can realize various different computing model infrastructures, such as web services, distributed computing and grid computing infrastructures.

[0176] A computer program (also known as a program, software, software application, app, script, or code) can be written in any form of programming language, including compiled or interpreted languages, declarative or procedural languages, and can be deployed in any form, including as a stand-alone program or as a module, component, subroutine, object, or other unit suitable for use in a computing environment. A computer program can correspond to a file in a file system. A computer program can be stored in a portion of a file that holds other programs or data (e.g., one or more scripts stored in a markup language document), in a single file dedicated to the program in question, or in multiple coordinated files (e.g., files that store one or more modules, sub programs, or portions of code). A computer program can be deployed to be executed on one computer or on multiple computers that are located at one site or distributed across multiple sites and interconnected by a communication network.

[0177] The processes and logic flows described in this specification can be performed by one or more programmable processors executing one or more computer programs to perform actions by operating on input data and generating output. The processes and logic flows can also be performed by, and apparatuses can also be implemented as, special purpose logic circuitry, e.g., an FPGA (field programmable gate array) or an ASIC (application specific integrated circuit). Devices suitable for storing computer program instructions and data can include non-volatile memory, media and memory devices, including by way of example semiconductor memory devices, e.g., EPROM, EEPROM, and flash memory devices; magnetic disks, e.g., internal hard disks or removable disks; magneto optical disks; and CD ROM and DVD-ROM disks. The processor and the memory can be supplemented by, or incorporated in, special purpose logic circuitry.

[0178] The subject matter described herein can be implemented in a computing system that includes a back end component, e.g., as a data server, or that includes a middleware component, e.g., an application server, or that includes a front end component, e.g., a client computer having a graphical user interface or a web browser through which a user can interact with an implementation of the subject matter described in this specification, or a combination of one or more such back end, middleware, or front end components. The components of the system can be interconnected by any form or medium of digital data communication, e.g., a communication network. Examples of communication networks include a local area network ("LAN") and a wide area network ("WAN"), an inter-network (e.g., the Internet), and peer-to-peer networks (e.g., ad hoc peer-to-peer networks).

[0179] While operations are depicted in the drawings in a particular order, such operations are not required to be performed in the particular order shown or in sequential order, and all illustrated operations are not required to be performed. Actions described herein can be performed in a different order.

[0180] Having now described some illustrative implementations, it is apparent that the foregoing is illustrative and not limiting, having been presented by way of example. In particular, although many of the examples presented herein involve specific combinations of method acts or system elements, those acts and those elements may be combined in other ways to accomplish the same objectives. ACTs, elements and features discussed in connection with one implementation are not intended to be excluded from a similar role in other implementations.

[0181] The phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of "including" "comprising" "having" "containing" "involving" "characterized by" "characterized in that" and variations thereof herein, is meant to encompass the items listed thereafter, equivalents thereof, and additional items, as well as alternate implementations consisting of the items listed thereafter exclusively. In one implementation, the systems and methods described herein consist of one, each combination of more than one, or all of the described elements, acts, or components.

[0182] Any references to implementations or elements or acts of the systems and methods herein referred to in the singular may also embrace implementations including a plurality of these elements, and any references in plural to any implementation or element or act herein may also embrace implementations including only a single element. References in the singular or plural form are not intended to limit the presently disclosed systems or methods, their components, acts, or elements to single or plural configurations. References to any ACT or element being based on any information, act or element may include implementations where the act or element is based at least in part on any information, act, or element.

[0183] Any implementation disclosed herein may be combined with any other implementation or example, and references to "an implementation," "some implementations," "one implementation" or the like are not necessarily mutually exclusive and are intended to indicate that a particular feature, structure, or characteristic described in connection with the implementation may be included in at least one implementation or example. Such terms as used herein are not necessarily all referring to the same implementation. Any implementation may be combined with any other implementation, inclusively or exclusively, in any manner consistent with the aspects and implementations disclosed herein.

[0184] References to "or" may be construed as inclusive so that any terms described using "or" may indicate any of a single, more than one, and all of the described terms. References to at least one of a conjunctive list of terms may be construed as an inclusive OR to indicate any of a single, more than one, and all of the described terms. For example, a reference to "at least one of 'A' and 'B'" can include only 'A', only 'B', as well as both 'A' and 'B'. Such references used in conjunction with "comprising" or other open terminology can include additional items.

[0185] Where technical features in the drawings, detailed description or any claim are followed by reference signs, the reference signs have been included to increase the intelligibility of the drawings, detailed description, and claims. Accordingly, neither the reference signs nor their absence have any limiting effect on the scope of any claim elements.

[0186] Modifications of described elements and acts such as variations in sizes, dimensions, structures, shapes and proportions of the various elements, values of parameters, mounting arrangements, use of materials, colors, orientations can occur without materially departing from the teachings and advantages of the subject matter disclosed herein. For example, elements shown as integrally formed can be constructed of multiple parts or elements, the position of elements can be reversed or otherwise varied, and the nature or number of discrete elements or positions can be altered or varied. Other substitutions, modifications, changes and omissions can also be made in the design, operating conditions and arrangement of the disclosed elements and operations without departing from the scope of the present disclosure.

What is claimed is:

1. An apparatus, comprising:

a load bank module configured to electrically couple with at least one other load bank module, the load bank module and the at least one other load bank module further configured to electrically couple to a power source to dissipate power received from the power source;

the load bank module comprising a plurality of trays comprising resistive components to dissipate the power received from the power source at a voltage level of the power source; and

a resistive component of the resistive components comprising a coil, the coil extending between a first end of the resistive component and a second end of the resistive component opposite the first end of the resistive component to form three or more turns of the coil.

2. The apparatus of claim **1**, comprising:

a plurality of load bank modules comprising the load bank module and the at least one other load bank module, the plurality of load bank modules having a total bottom surface area, the total bottom surface area comprising:

a length of 14.63 meters or less; and

a width 2.5 meters or less;

wherein the plurality of load bank modules are configured to dissipate at least 20 megawatts of power received from the power source.

3. The apparatus of claim **1**, wherein the voltage level is up to 33,000 volts alternating current.

4. The apparatus of claim **1**, wherein:

the load bank module has dimensions, comprising:

a length of 3 meters or less;

a width 2.5 meters or less; and

a height of 2.9 meters or less;

wherein the load bank module is configured to dissipate at least 4 megawatts of power received from the power source.

5. The apparatus of claim **1**, wherein:

the plurality of trays are stacked in columns within an enclosure of the load bank module, the plurality of trays electrically coupled together with bus bars;

a first set of the plurality of trays is coupled with a first phase of the power source;

a second set of the plurality of trays is coupled with a second phase of the power source; and a third set of the plurality of trays is coupled with a third phase of the power source.

6. The apparatus of claim 1, further comprising:

a first fuse configured to disconnect a first set of the plurality of trays from a first phase of the power source responsive to a level of current of the first phase exceeding a first threshold;

a second fuse configured to disconnect a second set of the plurality of trays from a second phase of the power source responsive to a level of current of the first phase exceeding a second threshold; and

a third fuse configured to disconnect a third set of the plurality of trays from a third phase of the power source responsive to a level of current of the first phase exceeding a third threshold.

7. The apparatus of claim 1, wherein the load bank module comprises a plurality of lateral sides, at least one of the plurality of lateral sides comprising a first rail;

wherein a tray of the plurality of trays comprises at least one second rail to couple with the first rail, the tray configured to install with the load bank module or uninstall from the load bank module via the first rail and the second rail.

8. The apparatus of claim 1, wherein a tray of the plurality of trays comprises at least one lateral wall comprising mica.

9. The apparatus of claim 1, wherein:

a tray of the plurality of trays comprises a lateral wall comprising a plurality of openings; and

the resistive components are configured to be inserted from a first side of the lateral wall, through the plurality of openings, to a second side of the lateral wall.

10. The apparatus of claim 1, wherein a tray of the plurality of trays comprises a lateral wall comprising a plurality of rows of openings from a bottom side of the lateral wall to a top side of the lateral wall, a first row of the plurality of rows of openings offset from a second row of the plurality of rows of openings towards a third side of the lateral wall that extends from the top side to the bottom side;

wherein the resistive components are configured to be inserted from a first side of the lateral wall, through the plurality of rows of openings, to a second side of the lateral wall.

11. The apparatus of claim 1, wherein:

a tray of the plurality of trays comprises a lateral wall comprising a plurality of openings;

the resistive components are installed within the tray, wherein bodies of the resistive components are at least partially disposed on a first side of the lateral wall;

at least a portion of the resistive components extend from the first side of the lateral wall, through the plurality of openings, to expose a plurality of terminals of the resistive components on a second side of the lateral wall; and

a plurality of bus bars configured to couple the resistive components via the plurality of terminals on the second side of the lateral wall.

12. The apparatus of claim 1, wherein the resistive component comprises:

a support member having a cylindrical shape, the support member extending from the first end of the resistive component to the second end of the resistive component;

a plurality of discs coupled with the support member and spaced between the first end of the resistive component and the second end of the resistive component, the plurality of discs comprising openings having circular shapes; and

a wire extending back and forth from a first end of the resistive component to a second end of resistive through the openings in the plurality of discs in a spiral pattern to form a plurality of turns.

13. The apparatus of claim 1, wherein the load bank module comprises a fan apparatus disposed between a bottom of the load bank module and the plurality of trays of the load bank module, the fan apparatus comprising:

at least one air guide vane configured to direct an airflow from a first direction ninety degrees to a second direction; and

a plurality of blowers configured to pull air from outside the load bank module and the air guide vane to direct the airflow away from the bottom to pass through the plurality of trays and cool the resistive components.

14. The apparatus of claim 1, wherein a tray of the plurality of trays comprises a first lateral side and a second lateral side opposite the first lateral side; and the apparatus further comprises a sensor comprising:

a body having a cylindrical shape; and

at least one sensing component disposed at least partially in the body to measure an environmental condition within a column of trays.

15. A method, comprising:

providing a support member having a cylindrical shape;

extending a coil between a first end of the support member and a second end of the support member opposite the first end to form three or more turns of the coil;

disposing the resistive component in a tray of a plurality of trays to dissipate power received from a power source; and

disposing the plurality of trays in a load bank module.

16. The method of claim 15, comprising:

stacking the plurality of trays in columns within an enclosure of the load bank module;

coupling a first set of the plurality of trays with a first phase of the power source;

coupling a second set of the plurality of trays with a second phase of the power source; and

coupling a third set of the plurality of trays with a third phase of the power source.

17. The method of claim 15, comprising:

coupling a first rail with a lateral side of a plurality of lateral sides of the tray of the plurality of trays;

coupling a second rail with a lateral side of a plurality of lateral sides of the load bank module; and

installing or uninstalling, via the first rail and the second rail, the tray with the load bank module.

18. The method of claim 15, comprising:

disposing a plurality of discs on the support member spaced from the first end to the second end; and

disposing a wire in the resistive component by passing the wire back and forth from the first end to the second end through openings in the plurality of discs in a spiral pattern to form a plurality of turns.

19. An apparatus, comprising:

a support member configured to install in, and remove from, a load bank, the support member comprising a first end and a second side opposite the first end; and a coil extending between the first end of the support member and the second end of the support member to form turns of the coil.

20. The apparatus of claim **19**, comprising:

a plurality of discs coupled with the support member and spaced between the first end of the support member and the second end of the support member, the plurality of discs comprising openings having circular shapes; and

a wire extending back and forth from a first side of the support member to a second side of support member through the openings in the plurality of discs in a spiral pattern to form the turns of the coil.

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